

ARTICLE III.—*A Preliminary Classification of Diptera, exclusive of Pupipara, based upon Larval and Pupal Characters, with Keys to Imagines in certain Families. Part I.* By J. R. MALLOCH.

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#### INTRODUCTION

Economic and taxonomic entomologists have long felt the need of a synoptic treatise on the immature stages of Diptera. Owing to the added impetus given to the study of this order by the comparatively recent discovery of the economic importance of certain members of the Diptera, the lack of available literature in English dealing with the larvae and pupae has been considerably emphasized. It is not the intention of the writer to attempt a definition of the larval and pupal characters that may be depended upon invariably for the separation of all the families of the order; a simple presentation of the main features involved in the differentiation of the families, genera, and species available to him is all that is attempted. It may be that these characters will in the main, with necessary modifications, prove of fundamental importance; but even if later they must needs be relegated to the category of things that have been they will at least have served the purpose for which they were intended—the identification of a number of important economic groups—and also constitute stepping-stones to the firmer ground that can be reached only by a more extended knowledge of the larvae and pupae, and by means of patient and intelligent comparative examination of a larger amount of material than is now at my command.

I have been requested by several of my entomological colleagues to undertake the task of presenting analytical keys to the immature stages of Diptera, but for lack of material that would add to the information already published I have hitherto refrained from doing so. I have been steadily acquiring material, however, for over two years, which, taken in conjunction with material previously in the collection here and that kindly loaned me, probably includes more examples of immature stages of Diptera as a basis for classification than have been brought together elsewhere in the United States. It is, moreover, my opinion that when any entomologist has a considerable amount of additional information upon any phase of a subject it is

incumbent upon him, in the interest of his fellow workers, to publish not only his new data, be they new species or life histories, but incidentally to link up with his data such facts already published as have a direct bearing upon the subject in hand. It undoubtedly takes valuable time to make a comparative description of a new species, and where several species in a genus require to be described it necessarily means considerable work to the describer to make a synoptic key to the whole genus as well as to give a description of each of the new species. But when one considers that the time so spent is infinitesimal as compared with that saved to subsequent workers who would otherwise have to puzzle over descriptions in order to discover the differentiating characters, it is evident that synopses and comparative descriptions are not only useful but should be regarded as indispensable in scientific work.

It is not with the intention of assisting the narrow specialist that this paper is written; the purpose is to enable the observant student of nature and the economic entomologist to recognize those forms that often come to their notice and thus obviate the frequent delays and discouragements in obtaining information through other channels. If this object is attained, even in a small measure, science will have gained some advantage and the author will be satisfied.

An effort has been made in the general discussions, and particularly in connection with life histories, to avoid the use of pedantic terminology, as the writer is of the opinion that except in formal descriptions clarity of expression can be attained and conciseness compassed by the use of language that is understood by the non-entomological reader, much of the terminology and phraseology incessantly cropping out in entomological publications being due either to the training or the personal whim of the writers.

This paper deals primarily with Illinois species, most of the material used having been collected in the state by the various members of the staff of the State Entomologist's Office or that of the State Laboratory of Natural History. In a few cases, however, I have used extralimital material belonging to our collections, and have also borrowed examples of either larvae or of pupae, or of both, which were not obtained in Illinois, in order to ascertain by an examination of the specimens information not included in previously published descriptions that would enable me to complete, as far as possible, data upon certain genera or species.

The classification adopted is essentially that used by Brauer in 1883\*; but in detail I have not accepted his arrangement, nor have I

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\*Denkschr. k. Akad. Wissensch., Wien, math.-naturw. Cl., 1883, pp. 1-100.

used his anatomical nomenclature, for, as has already been pointed out by Lundbeck in his "Diptera Danica", Brauer has erred in this paper in the interpretation of different parts of both larvae and pupae. These misinterpretations are not emphasized herein, as the present writer believes that in undertaking original work such errors are likely to occur, and that in viewing the results of the efforts of authors we ought to adopt a perspective that permits a correct appreciation of the difficulties under which the work was done. By this means we shall arrive at an estimate of the infinitesimal nature of existing blemishes in comparison with the immense advantages afforded to succeeding workers by a perusal of the author's published results. The present paper is presented without any foolish assumption of infallibility, and, as already stated, with a view to adding to the knowledge we already possess of the early stages of North American Diptera.

In order to keep the size of the paper within as small a compass as possible, descriptions of species published by the writer in previous papers are not reproduced, but citations are uniformly given to facilitate reference to them.

#### ACKNOWLEDGMENTS

I have to acknowledge the assistance rendered me in this study by the loan or gift of material as follows: from Dr. E. P. Felt, State Entomologist of New York; from W. L. McAtee, of the U. S. Bureau of Biological Survey; from J. J. Davis and J. A. Hyslop, of the U. S. Bureau of Entomology; from C. W. Johnson, of the Boston Society of Natural History; and from Dr. R. D. Glasgow, of the University of Illinois. In 1890-91 Dr. S. A. Forbes obtained a large amount of material from the streams and lakes in Yellowstone National Park, some of which represents genera and species of Diptera not in our collections from Illinois, and these have been used as a basis for contributory descriptions. Most of the material from the Illinois River which I have studied in this connection was collected by Mr. C. A. Hart, and some of it was used by him in preparing his paper on the Entomology of the Illinois River\*. Several of the species discussed or described were obtained by W. P. Flint and D. K. McMillan in the course of their field work for the State Entomologist's office.

#### HABITS AND HABITATS OF SPECIES

Under family headings and very frequently in the discussion of genera I have given notes upon the habits of larvae and imagines,

\*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI. (1895)

while in the case of species that I have reared the notes furnish data upon the habitat. This makes unnecessary preliminary details on these points. In fact the Diptera have such a variety of habits in the larval and imaginal stages, and are so generally distributed, that one might be pardoned if he were to dismiss the subject with the laconic remark, "omnivorous and omnipresent".

#### METHODS OF COLLECTION AND PRESERVATION

It is necessary, in my opinion, in papers of this nature to give some general directions regarding methods of collecting and, as a part of collecting, rearing species.

For the ordinary collecting of forms that frequent manure, decaying wood, fungi, and mud or comparatively dry earth, as well as phytophagous species, the best temporary receptacle is a small round tin box about an inch and a half in diameter and three fourths of an inch deep. Dealers in entomological supplies have these for sale, and they may be obtained with a paper-covered lid, upon the surface of which necessary data may be written. Many species may be reared to maturity in these boxes, the principal objection to this course being that it is not possible to learn whether the flies have emerged without opening the box, and frequently the specimen escapes upon the removal of the lid.

I have had very satisfactory results with rearing-cages consisting of Petri dishes, the upper dish fitting over the lower when inverted. These cages, especially in the spring, proved all that were required to produce imagines from the larvae of Empididae, Xylophagidae, Syrphidae, and many other families.

Aquatic species may be put in Mason fruit-jars or in small bottles, a convenient size of the latter being two-ounce. If not too tightly corked, specimens may be kept in such receptacles over night, but I find it best to use a cotton stopper instead of a cork unless while carrying the material in from the field. Many species, in fact most of the smaller forms, may be successfully reared in the two-ounce bottles, but I prefer to remove them during the pupal stage, or just before they transform to that stage, to a two-dram vial containing a little water and fitted with a cotton stopper. If transferred before transforming to the pupa the larval skin may be more easily found than in the larger bottle.

A mistake frequently made by entomologists in preserving larvae is to put the live specimens into 85% alcohol. This course almost invariably results in a shrinking of the skin and consequently seriously

impairs the value of the specimens. In order to procure the best results in the case of soft-bodied specimens it is especially necessary that the examples be placed at first in water, which should gradually be brought to the boiling point, or near it, and then set to cool. If the water is allowed to boil violently it often results in a distortion or over-expansion of the specimens. Upon removal from the cool water place the specimens in 25% alcohol to remain six or eight hours; next transfer them to 50% strength, in which they should remain twenty-four hours,—after which treatment the larvae may safely be transferred to 85% alcohol, in which they should be kept.

Pupal exuvia that have the integument chitinized may be preserved dry, but even such forms must be placed in alcohol if the imago has not emerged, as they shrink very much when preserved dry.

I have succeeded in obtaining presentable specimens from completely dried-out larval and pupal exuvia by boiling them in water. A larva or a pupa after drying out is rarely restored to its original form except by much patient work; but exuvia, even months after they have dried out, invariably recover their form when boiled.

The head parts are generally easily traceable in larval exuvia, but in preserved larvae, especially of Brachycera and Cyclorrhapha, in which the head is retracted, dissection must be resorted to in order to get at the internal structures. I have had some success in ascertaining these details when I did not wish to cut up the specimen, by boiling it in 10% potash; but this is a tedious operation, especially if the specimen is a large one, and I prefer to expedite matters by cutting off the anterior two thoracic segments—caudad of which the cephalic skeleton does not extend—which may readily be cleared so that dissection is possible in a few minutes.

The larger species have such heavily chitinized opaque heads that they are not good objects for slide mounts, but the smaller ones should invariably be mounted in Canada balsam. It is always necessary that some system of cross-reference be used for slide, vial, and imago in order to facilitate reference.

More detailed information upon methods of mounting specimens is given in my article on the Chironomidae of Illinois.\*

#### ECONOMIC IMPORTANCE OF THE ORDER

No other order of insects equals the Diptera in diversity of habits in larval and imaginal stages. Many of the families are largely beneficial, but unfortunately the good done by them is counterbalanced by

\*Bull. Ill. State Lab. Nat. Hist., Vol. 10, Art. VI. (1915)

the injury inflicted by others. The essentially phytophagous families, that is those families of which the great majority of the species feed upon plants, are very greatly outnumbered by those that are scavengers or predaceous or parasitic. If we exclude those that are fungivorous, only four families remain that can be classed as preponderatingly phytophagous—*Cecidomyiidae*, *Trypetidae*, *Agromyzidae*, and *Chloropidae*; a few species in these families are predaceous. It must be borne in mind that a phytophagous species is not necessarily injurious from the economic standpoint, as many species feed upon and keep in check noxious plants and may therefore be regarded as beneficial.

It is but a step from the phytophagous to the scavenging habit, and in *Drosophilidae* we find species that may feed upon *Cruciferae*, mining the leaves, or in sap exuding from trees and in vegetable refuse. Few other scavenging Diptera feed upon living plants, the only additional exception known to me being those that are fungivorous. There are eight families that may be considered as essentially fungivorous—*Macroceridae*, *Bolitophilidae*, *Platyuridae*, *Mycetophilidae*, *Sciaridae*, *Platypezidae*, *Phoridae*, and *Drosophilidae*. Many of the *Sciaridae* occur in decaying vegetation, while the habits of *Phoridae* are remarkably diverse, some being true entoparasites.

The scavengers belong to more than a score of families. In *Muscidae* all the species scavenge; but in some other families, *Anthomyiidae*, for example, we find phytophagous and inquiline species, though these are greatly in the minority and the family is essentially one of scavengers. The *Sarcophagidae* include some species that are true entoparasites, but the great majority are feeders upon decaying animal and vegetable matter. The scavengers are in the great majority of cases really beneficial, transforming dead animal and vegetable matter into such forms as can be utilized as food by growing plants. In reducing the bulk of putrefying substances, which, absorbed by the growing larvae, are transformed into the bodies of the resultant imagines, they remove what is noxious to man. It is chiefly when scavengers such as the common house-fly contaminate our food by contact, after feeding on foul substances which are impregnated with disease germs, that there is real danger from these insects. Rarely the screw-worm fly and some of the flesh-flies deposit their eggs or larvae in wounds, either on man or on animals, and in this manner produce serious ulcerations, and the larva of the former has been known to cause the death of persons by penetrating the brain, which it entered by way of the nasal passages. The flesh-flies and some other groups sometimes cause myiasis in man, the larvae finding their way into

the stomach with food in which the flies have deposited their eggs or larvae and which has not been prepared for consumption by judicious cooking, or carefully examined so as to exclude infested portions.

We may class as true parasites nine families, some of which, as Tachinidae (*sens. lat.*), Dexiidae, and Pipunculidae, are highly beneficial, and others, as Gastrophilidae, Hippoboscidae, and Oestridae, are distinctly injurious. The parasites of this order destroy many injurious species of insects, and, next to the parasitic Hymenoptera, constitute the most important check upon their increase.

Another group of highly beneficial species is that containing the predaceous forms. Two of the families which are to some extent beneficial in the larval stage—Tabanidae, and Culicidae in part—are injurious as imagines, turning their attention from insect larvae, on which they chiefly prey in the early stage, and giving it largely to mammals, including man. This radical change of habit is, however, exceptional, as other predaceous families in this and other orders feed upon insects in both the larval and imaginal stages. Many Syrphidae are aphidophagous as larvae, the greater portion of the species being scavengers, while the imagines are flower-frequenters.

The aquatic families, with the exception of the Sciomyzidae and Ephydriidae, which are in large part aquatic, belong to the Orthorrhapha. With the exception of the Mycetophiloidea, which contains five families, the Oligoneura, which contains the Cecidomyiidae, and the families Bibionidae and Scatopsidae, all the families in the division Nematocera are aquatic either wholly or in large part. The aquatic species in the division Brachycera are contained in five families—Leptidae, Stratiomyidae, Tabanidae, Empididae, and Dolichopodidae. As already indicated in the foregoing general discussion, the larvae of some of these families are predaceous and may justly be considered beneficial; the others feed upon algae and decaying vegetable matter, and while their presence in water that is intended for drinking purposes is undesirable it is not necessarily harmful unless the vessel containing them is small and they are numerous enough to foul the water, either with excreta or exuvia. With the exception of some Chironomidae and Culicidae there are few species that frequent reservoirs or cisterns, most of them preferring lakes, ponds, or streams.

My information regarding the habits of the order in general leads me to the conclusion that as a whole their beneficial and injurious activities practically offset each other. The fact that there are injurious species which cause great recognized damage, such as the malarial and other disease-bearing mosquitoes and the Hessian fly, very largely outweighs in the mind of the uninformed the benefits—

few of which are apparent except to a student of the Diptera—that are directly or indirectly due to the presence of other forms. With advance in a knowledge of the biology of the insects of this order will come a realization that their injurious and beneficial effects are practically balanced.

#### ARRANGEMENT OF FAMILIES

In agreement with the method generally used by systematists in zoological work, the arrangement of the Diptera is in accordance with the generally accepted theory of evolutionary development, and the families are thus arranged as nearly as possible in their natural sequence from lowest to highest, using as criteria the rather limited data furnished by available life histories, and by a study of imaginal characters; but in endeavoring to trace affinities the reader must bear in mind that the families included are but the tips of the evolved branches, and not the entire genealogical tree. The hypothetical primitive dipterous larva is assumed to have had a complete head with horizontally moving mandibles, the head enclosing the first ganglion; three thoracic segments, the prothoracic with a pair of spiracles; and ten abdominal segments, the anterior seven, or more, with lateral abdominal spiracles. No larva of this order has yet been discovered which possesses true thoracic legs, but there are many species that have pseudopods or sensory organs upon some of the thoracic segments. This anatomical feature is not accounted as pertaining to a consideration of the phylogeny of the group, as pseudopods are generally regarded as of secondary importance, being developed, partially developed, or absent, in species within the same family.

The head is the best single unit available under all circumstances for the purposes of classification, as it is wholly or in large part chitinized and its component parts are accessible for examination either as a composite mass or after dissection, even in alcoholic material, whereas the nerve ganglia and even the tracheal system of alcoholic material are often indistinguishable, and in the case of exuvia entirely lost. The modifications exhibited in the head of the different families are remarkable, and though there are rather abrupt breaks in the chain of ascent as we pass from the Nematocera, with their opposed mandibles and complete or almost complete head-capsule, to the Brachycera, with their vertical subparallel mandibles and much reduced head-capsule, and, again, from the higher forms of this group to the Cyclorrhapha, and particularly to the Muscidae, one can trace with considerable probability the line of evolution up to the most highly

specialized forms of the present day. In this paper a large series of figures of heads of larvae belonging to all the principal sections is given in order to exemplify the evolutionary phases and, incidentally, to permit the student to judge as to the correctness of the classification by a comparison of the available data thus presented in the most readily comprehensible manner. An unillustrated discussion of anatomical details affords no check on possible misstatement or misinterpretation by an author or on misconstruction of his words by the student, and to prevent error from one source or another such discussions should be accompanied by figures.

Brauer divided the Orthorrhapha into three tribes, Eucephala, Polyneura, and Oligoneura, using the structure of the head as his primary character in separating the groups, Eucephala having the head entire, the others having the head-capsule incomplete posteriorly. Oligoneura has in addition to an incomplete head-capsule vestigial mandibles, a character which separates the tribe from the other two. Brauer's classification has been generally accepted, though several writers have pointed out what they consider to be errors in grouping that result from the application of his rules, and Sharp has gone so far as to suggest that his system has been influenced by his use of dichotomic tables\*.

Recently a suggestion has been made that as the group Nematocera is apparently an unnatural one, containing, as it does, some widely dissimilar families which fall together according to Brauer's classification, we should attach primary importance, not to the structure of the head but to the respiratory system†. Here, again, an arbitrary attempt has been made to divide the group Nematocera into two tribes, Oligoneura and Polyneura, using the respiratory system as a basis for the division. In some respects the suggestion is an improvement upon Brauer's system of classification, but even so, the composition of both groups shows some confusion which to my mind proves that the respiratory system is not an ideal character on which to base tribes. In fact the only point clearly shown is that some species of all of the families of Oligoneura, rarely, all species of some of them, are peripneustic and hence assumably primitive structurally, while all species, so far as is known, in Polyneura are amphipneustic, metapneustic, or apneustic. That there are both metapneustic and apneustic forms in Oligoneura of this latter classification, and that several have the lateral abdominal spiracles functionless and may

\*Verrall's "British Flies", Vol. 5, p. 31. (1909)

†Knab, in Ann. Ent. Soc. Amer., Vol. 7, 1915, p. 93.

therefore be considered as amphipneustic does not seem to have much weight with those who follow this dichotomous arrangement. Peripneustic larvae occur in Dolichopodidae and vestigial spiracles are present in some Stratiomyidae—facts which point, not to the more primitive nature of the species possessing these organs but to the persistence of the latter because of their utility in the larval habitat.

There must be a further division of the tribes in Diptera, but until we have data upon a larger number of species in the order any proposed subdivision, including that of the present paper, must necessarily be merely tentative. I give a figure of a hypothetical genealogical tree of Orthorrhapha which illustrates my opinion of the relations of the various families (Fig. 1). There are defects in the scheme that will probably be obvious to many, and it remains for some future worker to improve on the suggestion here given. The sequence of families in this paper is according to the author's ideas, differing somewhat from that in Williston's "Manual", but subject to amendment upon discovery of new data.

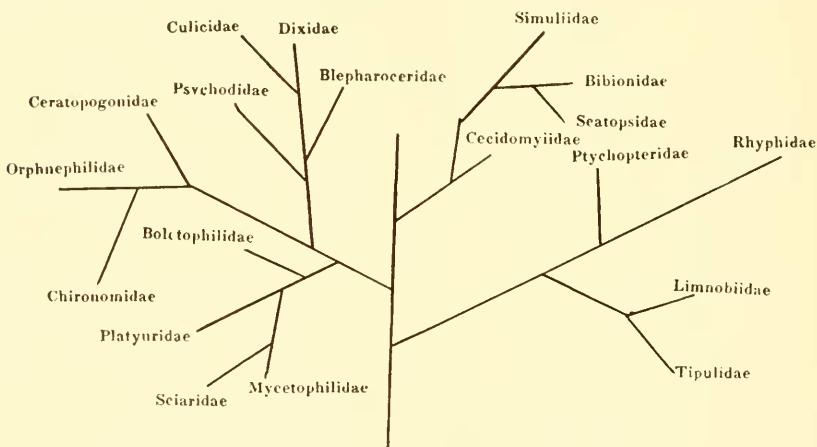


FIG. 1. Hypothetical genealogical tree of Nematocera, illustrating the grouping in this paper.

The nervous system as a means of identification may be eliminated because of its limited applicability—in preserved material—but we may with little reserve accept as one of the primary indices to affinities the nature of the respiratory system. Insects normally breathe by means of thoracic and abdominal spiracles, and these are found in the adults and in a great majority of the pupae of the Diptera. It is the exception, however, to find them in the larvae, and as a means of

identifying those of many of the lower families the absence or presence of the lateral abdominal spiracles is of considerable importance. It is not to be expected that a rule will be discovered as to the absence or presence of these spiracles which will be of invariable applicability to all the families—as at present constituted—in the Nematocera, because we find, from data already in hand, that there appear to be several exceptional genera within the group, and also because peripneustic larvae occur in much higher families. Taken in conjunction with the structure of the head, however, it is quite possible that the absence or presence of the lateral abdominal spiracles may prove to point to the tracheal system as of primary importance in classification. It must be borne in mind that many families as at present constituted include genera whose larvae have widely different habits, both terrestrial and aquatic forms occurring at times in closely allied genera and, rarely, within the same genera. In this connection it seems pertinent to indicate that our system of arrangement is based primarily upon the characters possessed by the imagines, but investigators may, without compunction, remedy errors in the system which, by an examination of the immature stages, are shown to exist.

One of the principal characters cited by Brauer for the separation of the Orthorrhapha from the Cyclorrhapha is the nature of the splitting of the larval skin when the pupa or adult emerges. In the former the skin splits on the dorsum in the shape of a T or +; whereas in the latter—in which the skin hardens in the last stage to form an enclosing puparium—the splitting is usually transversely across the entire dorsum and venter, so that the anterior portion of the puparium comes off cap-like; or there may be also lateral splits that cause the upper and lower halves of the anterior portion to separate. The lines of dehiscence in Cyclorrhapha puparia are not accidental, but are clearly provided for by weak parts in the membrane. The emergence of the imago in Orthorrhapha is assisted by a slight swelling in the thoracic region, and by movements of the developing wings and hardening legs; in Cyclorrhapha the operation is facilitated by the dilation, with air, of a bladder-like sac immediately over the antennae, which, when swollen, forces apart the anterior extremity of the puparium along the lines indicated by the thinner membrane. After emergence the ptilinum, as the bladder-like structure is called, is retracted within an aperture above the antennae and forms a pouch-like cavity. The existence or absence of this peculiar structure in the imagines constitutes the primary character for the separation of the two suborders—Orthorrhapha being without and Cyclorrhapha with a ptilinum, its presence being indicated by what is called the frontal triangle, im-

mediately above the antennae. The families Lonchopteridae, Pipunculidae, and Platypezidae have a very poorly developed ptilinum or it is undeveloped, but other characters appear to align them with Cyclorrhapha.

In the Orthorrhapha, the imagines of the Nematocera have the antennae usually much elongated and consisting of 7 or more distinct joints; the Brachycera have the antennae consisting of 3 joints, the third being either simple or composed of a number of closely fused ring-like joints having the appearance of an elongated single joint with more or less distinct subdivisions, and there is also, sometimes, a terminal or dorsal arista or style. In the Cyclorrhapha the antenna consists of 3 joints and a terminal or dorsal arista, the second joint in some families being small and entirely or almost entirely enclosed within the very large third, so that the antenna appears to consist of only 2 joints. The wing veins offer a good character for the differentiation of the families throughout the order, and being readily accessible have been made much use of by taxonomists. The lower forms have a much larger number of longitudinal veins than do the higher, and this seems to point to a coincident reduction of antennal segmentation and wing venation in the evolution of the families of the order.

An interesting piece of histological work might be undertaken in connection with the development of the members of the Muscidae and allied families, particularly in the observation of the developmental processes of the head-parts, which are so much reduced in the larvae of these forms.

I present in this paper a key to the imagines of the families of North American Diptera based upon the most recent data available. I have made use of many characters that are not in existing text-books, and in doing so I have simply attempted to put into writing data that many specialists merely carry in their minds. The characters used by Schiner and others for the separation of European families and genera are as a general rule applicable to North American Diptera, but there are many intermediate forms here that do not occur in Europe, and as the keys in use here have largely been copied or adapted from those in use in Europe considerable discretion is required in locating members of many families by these keys. The described dipterous fauna of this country is growing beyond the possibility of competent handling by one individual, and frequently men who are authorities on certain groups are unable to do more than make a guess at the family status of a particular species. I make this explanation in the hope that students will realize certain facts: that the beginner in the study is facing a stiff task in this order; that the knowledge we possess concerning

the order is comparatively meager; and that I realize the possibilities of error that beset me in the present attempt.

#### SCOPE OF WORK

In order to keep the size of this paper within a reasonable compass I have given generic keys to imagines of those families only that are not correctly dealt with in Williston's "Manual of North American Diptera".

I have covered the larval and pupal stages of all the groups available to me, depending but rarely upon printed descriptions for differentiating characters. In the Orthorrhapha I have succeeded in obtaining larvae or pupae, or both, of all the families except Macroceridae, Orphnophilidae, Nemestrinidae, and Apioceridae. The Cyclorrhapha are not so fully represented, but I have a large quantity of material on hand which will serve as a basis for an extensive paper on this group, and this will be published as Part II of the present article.

A bibliography of general papers on Diptera will be given at the conclusion of Part II, and papers upon single families will be listed in connection with the text dealing with such families.

#### CHARACTERS OF THE LARVAE

##### Suborder ORTHORRHAPHA

###### Division NEMATOCERA

Broadly speaking, the dipterous larvae of Brauer's eucephalous group of the Nematocera may be distinguished from those of other Diptera and also from other orders, by the following characters.

Head with opposed, usually toothed, mandibles, often, in the aquatic or semiaquatic forms, with conspicuous brushes on their external surfaces; variously constructed antennae which may be barely distinguishable elevations (Mycetophilidae, Sciaridae) or elongated, and consisting of from 1 to 6 joints and occasionally retractile within the head (Tanyypinae); well-developed maxillae with 1- or 2-jointed palpi; no well-developed labial palpi; a more or less chitinized labial plate, or submentum, which is frequently dentate upon its anterior margin; eyes, when present, indicated by a single or double pigmented area on each side. True legs never present; prothoracic segment occasionally with a pair of pseudopods which may be entirely or partly fused (Chironomidae, Simuliidae); anal segment in some cases with a pair of more or less elongated pseudopods which are sometimes armed with curved retractile claws in 2 or more concentric series;

abdominal, and occasionally also thoracic, segments sometimes with locomotor spinules in transverse series on portions of their ventral surface (Mycetophilidae, part) or with pseudopod-like elevations or fusiform transverse locomotor areas; respiratory system consisting, in its highest development, of 1 pair of prothoracic, 7 pairs of abdominal, and 1 pair of anal spiracles, the abdominal pairs not functional in some cases (Simuliidae, and Bibionidae and Scatopsidae ?), while in other families they are absent entirely, respiration being carried on either by means of the anal spiracles, or by these and the prothoracic pair, or by means of blood-gills on the anal segment which are sometimes retractile (Simuliidae, Ceratopogonidae) or permanently exserted (*Chironomus*, part).

The acephalous larvae differ very markedly from those of the other group in the reduction of the head-capsule. In Cecidomyiidae the mandibles are vestigial or absent and the posterior portion of the head is poorly defined and membranous, but the larvae may be distinguished by the presence of 13 segments, in addition to the head; by the lateral abdominal spiracles; and, usually, in the last instar, by the presence, on the ventral surface of the first and second thoracic segments, of a chitinized plate, generally referred to as the "breast-bone", which is differently shaped in different species and is used by the mature larvae as a means of propulsion in making their leaps after leaving their cells for pupation—in cases where this change is made in the ground. In other larvae of this group there are at most but 12 distinct segments in addition to the head.

The reduction of the head-capsule in Tipulidae and Limnobiidae is in the form of a breaking up of the fusion of the component parts posteriorly, the caudal portion of the head thus having the appearance of several slightly diverging rods, the membrane of the prothorax being attached to the head just anterior to the point of divergence. These larvae may be distinguished from those of the higher families of the Brachycera by their opposed, instead of parallel, mandibles. Respiration is carried on by means of prothoracic and anal spiracles—the latter supplemented in the aquatic forms by retractile blood-gills on the ventral surface of the last segment—or in some genera by the anal spiracles only.

#### Division BRACHYCYCERA

The larvae of Brachycera are usually readily distinguished by the large maxillae, with their normally conspicuous palpi, between which are the slender labrum and the vertically moving, knife- or sickle-shaped mandibles on each side of it. The antennae are sometimes conspicuously elevated but occasionally very short, and the eyes

are often readily distinguishable. The head is usually almost fully retractile within the thorax, being permanently exserted in Xylophagidae, Coenomyiidae, and Stratiomyiidae. Respiration in this group is normally carried on by means of prothoracic and posterior spiracles, the latter being situated upon the ultimate (Stratiomyiidae, Leptidae, etc.), penultimate (Asilidae, Mydidae, Bombyliidae), or antepenultimate (Therevidae, Scenopinidae) segments. Some species of peripneustic Dolichopodidae are an exception to this rule. Many species of Brachycera have on their ventral surface locomotor organs, which may consist of mere transverse irregular swellings (Asilidae, in part, Mydidae, Bombyliidae, etc.), paired pseudopods (Leptidae, part), or transverse series of spinules (Xylophagidae). Many of the families have conspicuous bristles on the body surface, especially on the ventral surface of the thoracic segments and the dorsal and apical surfaces of the anal segment (Asilidae, Mydidae), or on all of the thoracic and abdominal segments (Xylophagidae, Stratiomyiidae).

The normal number of segments in this group is 12, exclusive of the head; but in several families—Tabanidae, Stratiomyiidae, Leptidae—only 11 are distinguishable. Except in the Stratiomyiidae the pupa is free, that is to say, not enclosed in the indurated larval skin. Rarely the pupa is enclosed in a loose cocoon (*Medeterus*) or in a very compact one (*Drapetis*).

#### Suborder CYCLORRHAPHA

##### Division ACROPTERA

This group includes but one family, Lonchopteridae. The systematic position of the group has long been in doubt, but the most recent and comprehensive work upon all stages of the species clearly points to their much closer affinity with the Cyclorrhapha than with the Orthorrhapha. The larvae are distinguishable from those of other Diptera by the fact that they have but 9 well-defined segments in addition to the head.

A full discussion of the characters of this group appears under the family heading on a subsequent page.

##### Division ASCHIZA

This group consists of Syrphidae, Pipunculidae, Platypezidae, and Phoridae, according to Brauer. I have before me larvae and puparia of all but Pipunculidae. The cephalopharyngeal skeleton is better developed in this group than in Schizophora, but it is less perfect than in the most specialized orthorrhaphid larva. In the aphi-

dophagous Syrphidae there are upper and lower chitinized mouth-hooks, which consist of two convergent lateral pieces with a V-shaped anterior extremity and correspond to the pair that are present in Schizophora; but in addition to these there are two to four pairs of small chitinized points or hooks which work horizontally and serve the purpose of grasping prey. The mouth-hooks in Schizophora are not V-shaped and the lower one is absent. These chitinized pieces are less readily distinguishable in the aquatic Syrphidae but are present in modified form, while the mouth-margin is specialized. The antennae in all species of the latter family are distinct, usually consisting of a single joint, rarely two, with a pair of short apical processes. The body consists of 12 segments, but the segmentation is indistinct because of the presence of numerous transverse wrinkles or folds in the integument; the surface of the body in most species bears regularly arranged bristles, which are occasionally upon slight elevations and serve to distinguish the different segments. Pseudopod-like structures are often present on ventral abdominal segments, their apices armed with short bristly hairs. Respiration is by means of prothoracic and anal spiracles, the former occasionally doubtfully functional or apparently absent, the latter protruding occasionally in a tube-like appendage.

The larvae of Platypezidae resemble some of the Syrphidae rather closely, and bear a striking resemblance to the anthomyiid subfamily Fanniinae in having fringed projecting processes on the body segments. The more elaborate mouth-parts readily separate them from all Anthomyiidae, and also, in my opinion, associate them more closely with Syrphidae than with Phoridae, though Brauer places them with the latter in the tribe Hypocera.

The Phoridae are much simpler in general form than most Syrphidae and all described Platypezidae, possessing, in as far as they are known, no prominent body appendages. The mouth parts are similar to those of the other families of the group in having anteriorly fused mouth-hooks. The larvae are amphipneustic—possessing prothoracic and anal spiracles.

The transformation to the pupa takes place within the last larval skin.

#### Division SCHIZOPHORA

The larvae of this group, which contains a great majority of the members of this suborder, are readily distinguished from those of any other order by the remarkable reduction of the head, which, when seen laterally, consists of a V- or U-shaped chitinized posterior plate, which has two posteriorly divergent dorsal rods, and, attached to the

anterior extremity of this plate, another, smaller plate, which is anteriorly curved downward and consists of two—rarely one—hooks or mandibles which are either simple or toothed and operate vertically, scraping or abrading the surface of the larval pabulum so that the food is drawn downward and inward to the mouth cavity. These mouth-hooks, and the entire cephalopharyngeal skeleton, are retracted when the larva is at rest. The respiratory system consists of prothoracic and anal spiracles which are connected by means of two large main tracheae, the latter being normally connected by means of a slender transverse trachea just behind the prothoracic spiracle, and each sending out upon each segment a stout downwardly and slightly forwardly directed stout trachea with numerous branches, and, in addition, a smaller trachea, which is an offshoot from the inner surface and is directed almost straight cephalad. The structure of the spiracles is of great value as a character in the classification of this group. The anterior spiracles are often questionably functional in the aquatic forms, and are sometimes almost or entirely absent in parasitic species, the connection with the air being maintained entirely by means of the posterior pair. Means of locomotion in this group consist of spines on various portions of the thoracic and abdominal segments, with, occasionally, poorly developed pseudopods on the abdominal segments, particularly on the apical segment. Rarely there are elaborate appendages upon the thoracic and abdominal segments (Fanniinae), but more frequently the surface of the segments is bare except for the locomotor organs. The larvae transform to the pupal stage within the indurated last larval skin, which is then referred to as the puparium. In this stage characters are frequently developed that are of value in classification; these are dealt with in the section upon characters of the pupae.

#### CHARACTERS OF THE PUPAE

##### Suborder ORTHORRAPHA

###### Division NEMATOCERA

The aquatic members of this group may in the main be separated from those of the Brachycera by their stalked prothoracic respiratory organs, which are occasionally numerously filamented apically. The few species that are recorded as having these organs sessile may be distinguished from brachycerous pupae by the peculiar recurving of the legs against the ventral surface of the base of the abdomen and the posterior portion of the thorax (Chironomidae). The terrestrial species are distinguishable from brachycerous forms by the very long antennal sheaths which curve over the upper margin of the eyes;

whereas in the Brachycera they are either short and inconspicuous or project almost in a straight line across the front of the head, being usually armed with thorns, or they project divergently downward and are frequently armed with strong thorns. The abdomen has usually 7 pairs of lateral spiracles, but in most of the aquatic forms these are not distinguishable.

#### Division BRACHYCERA

As mentioned under the previous heading, the pupae of this group very frequently have spines on the antennal sheaths and, in addition, similar spines on protuberances on the face or other portions of the head, and also on the thorax. The prothoracic spiracles are sessile or but slightly elevated except in some Empididae and Dolichopodidae. The abdomen has 7 pairs of lateral spiracles; the segments usually have girdles (1-2) of spines, thorns, or hairs; and the apical segment is usually armed with two or more strong terminal spines or stout processes. Only in the case of the Stratiomyiidae are the pupae enclosed in the last larval skin.

The pupae of Coleoptera and Hymenoptera may readily be separated from those of Diptera by the mandibulate mouth-parts and the presence of four wing-pads, while the latter character will also separate those of Lepidoptera, though usually the under wings, or posterior wings, are visible only in the form of a narrow strip along the caudal margins of the front pair.

#### Suborder CYCLORRHAPHA

##### Divisions ACROPTERA, ASCHIZA, AND SCHIZOPHORA

All the divisions of this suborder may be distinguished by the fact that the pupae are enclosed within the indurated last larval skin. The absence of a well-developed head will readily separate the puparia of this suborder from those of Stratiomyiidae; in the case of Lonchopteridae, which resemble the latter family, there is no distinct head, there are only 9 distinct segments, and on the dorsum of the second abdominal segment there are horn-like respiratory organs as in Phoridae. The chitinized structure of the puparia itself will serve to separate them from those of the Cecidomyiidae that pupate under similar conditions, the integument of the latter being of a rather flimsy nature.

In Lonchopteridae, Syrphidae, Phoridae, and many Muscidae and Anthomyiidae a pair of thoracic respiratory organs are developed upon the first or second abdominal segment in the puparia. These organs do not appear until the pupa is formed, and their mushroom-like sprouting comes rather as a surprise to the observer.

Many species that ordinarily make primary, if not exclusive, use of the anal respiratory organs while in the larval stage make exclusive use of the prothoracic spiracles in the pupal stage. This is noticeably so in species that live under aquatic or semiaquatic conditions.

#### KEYS TO SUBORDERS

##### LARVAE

1. Head complete, or the posterior portion with deep longitudinal incisions; mandibles moving horizontally.....  
..... *ORTHORRHAPHA-NEMATOCERA*.
- Head incomplete, without a strongly developed upper arcuate plate; mandibles moving vertically.....2
2. Maxillae well developed, their palpi distinct; mandibles normally sickle-shaped, not protruded much beyond the apices of the maxillae, often extending less than half-way to their apices; antennae well developed, situated upon the upper surface of a slightly arcuate chitinized dorsal plate.....  
..... *ORTHORRHAPHA-BRACHYCERA*.
- Maxillae poorly developed, their palpi visible only in a few groups; mandibles short and hook-like, usually capable of protrusion much beyond apices of maxillae if these are present; antennae poorly developed or absent, when present situated upon a membranous surface .....*CYCLORRHAPHA*.

##### PUPAE

1. Pupa not enclosed within the indurated last larval skin, or if so the head is distinct as in the larva, or the puparium is slightly flattened dorso-ventrally, its texture leathery, not chitinous, and the anterior respiratory organs not distinguishable; imago, or pupa, emerges through a rectangular split on dorsum of larval skin...  
..... *ORTHORRHAPHA*
- Pupa enclosed within the indurated last larval skin; head always retracted, the chitinous portion occupying a position on the inner side of the ventral surface of the puparium; anterior respiratory organs distinct, either protruded from the antero-lateral angles of the cephalic extremity or from dorsum of base of abdomen; imago usually emerges by forcing off the rounded anterior extremity of the puparium in cap-like form, or the dorsal half of the thoracic portion—the lines of cleavage being along the lateral margins to a point at base of abdomen; rarely emergence is through rectangular splitting of the dorsum of the puparium...  
..... *CYCLORRHAPHA*.

## IMAGINES

1. Antenna consists of a 2-jointed scape—the basal joint usually indistinct—and a distinctly segmented flagellum of more than 2 joints ..... *ORTHORRHAPHA*, pt.
- Antenna consists of apparently 2 or 3 joints and, usually, a terminal or dorsal arista ..... 2
2. Frontal lunule absent ..... *ORTHORRHAPHA*, pt.
- Frontal lunule present, or if poorly developed or apparently absent there are no distinct cross-veins on disc of wing ..... *CYCLORRHAPHA*.

Suborder *ORTHORRHAPHA*

## KEYS TO DIVISIONS

## LARVAE

1. Head complete, or sometimes incomplete posteriorly; mandibles absent or vestigial in Cecidomyiidae, but the body consisting of 13 segments in addition to the head, in other families mandibles present, moving horizontally or nearly so, their position when at rest being on a horizontal plane, or varying but slightly from it, their apices opposed; labium usually well developed, in the form of a flat plate with or without dentate anterior margin; larvae frequently peripneustic, the aquatic forms usually with protrusive anal blood-gills ..... *NEMATOCERA* (p. 182).
- Head always incomplete and partly retracted within the prothorax; mandibles moving vertically, their position when at rest vertical, the apices parallel and directed downward; labium poorly developed, rarely or never in the form of a flat plate; larvae normally amphiapneustic or metapneustic, very rarely peripneustic, aquatic forms without protrusive anal blood-gills ..... *BRACHYCERA* (p. 307).

## PUPAE

1. Head, except in some Cecidomyiidae and a few Tipulidae, without strong thorns; antennae much elongated, always very distinctly traceable, normally curved well over upper margin of eyes and extending to or beyond base of wing, in some cases almost to apex of wing; thoracic respiratory organs much elongated or sessile; legs of variable length, often extending to apex of abdomen, rarely slightly longer than wings, in aquatic forms often recurved against base of abdomen; abdomen in species with short antennae sometimes unarmed ..... *NEMATOCERA* (p. 182).
- Free except in Stratiomyidae; head in other families usually with

strong thorns, or if these are absent the antennae are very short and project downward and outward and do not curve over the upper margin of the eye or reach nearly to base of wing; thoracic respiratory organs sessile, rarely stalk-like; legs of variable length; abdomen usually armed with strong spines or bristles, or if unarmed there are only 4 or 5 distinct pairs of abdominal spiracles.....BRACHYCERA (p. 307).

#### IMAGINES

1. Antenna consisting of at least 7 joints, frequently filiform, rarely conspicuously thickened, but if so the joints are distinct and the flagellum does not appear as a single joint with poorly defined subdivisions, and the palpi are pendulous, consisting of 4 or 5 joints; antennae with or without whorls of hair on the joints, never with a terminal arista or style; palpi always pendulous, normally consisting of 4 or 5 joints, very rarely of only 2.....NEMATOCERA (p. 182).
- Antennae consisting of 3 joints, the third occasionally having more or less distinctly annulated subdivisions, but in such cases the palpi are porrect and consist of 1 or 2 joints; antennae with short pubescence or with thick branches, in some families with either a terminal or subterminal style or arista; palpi projecting forward, consisting of 1 or 2 joints.....BRACHYCERA (p. 307).

## Division NEMATOCERA

## TABULAR ARRANGEMENT OF FAMILIES

My present grouping of the Nematocera is as follows.

<i>Tribes*</i>	<i>Superfamilies</i>	<i>Families</i>
Polyneura	Tipuloidea	Tipulidae Limnobiidae Ptychopteridae Rhypidae
Eucephala	Mycetophiloidea Culicoidea Chironomoidea	Bolitophilidae Mycetophilidae Sciaridae Macroceridae Platyuridae Psychodidae Blepharoceridae Culicidae Dixidae Ceratopogonidae Chironomidae Orphnophilidae
Oligoneura	Cecidomyioidea Bibionoidea	Cecidomyiidae Bibionidae Scatopsidae Simuliidae

The sequence of the families in the keys is not in accordance with the above list, the keys being framed to facilitate identification and not to indicate affinities.

\*Tribe in this paper does not have the application given to it in contemporary papers, but has that which Brauer gave it. He used it to designate his subdivisions of the larger divisions of Nematocera, etc.

## KEYS TO FAMILIES

## LARVAE

1. Head incomplete; thorax and abdomen combined consisting of 13 segments; larvae peripneustic; usually with a chitinized plate (very distinct in mature larvae) on ventral surface of second thoracic segment.....CECIDOMYIIDAE (p. 293).
- Without the above combination of characters.....2
2. Head and thoracic and first and second abdominal segments fused; larvae with minute abdominal spiracles; abdomen with a ventral longitudinal series of sucker-like discs.....BLEPHAROCERIDAE (p. 274).
- Head free, or if retracted within or fused with prothoracic segment the other thoracic segments are distinct.....3
3. Head complete, enclosing first ganglion; mandibles opposed.....5
- Head incomplete posteriorly, either with 3 deep wedge-shaped slits, 2 on dorsum and 1 on venter, or the ventral surface very poorly chitinized and the dorsal one posteriorly in the form of 4 slender heavily chitinized rods, with a weakly chitinized divided plate on anterior half of the dorsum.....4
4. Apical abdominal segment with 6 radiating protuberances, which are rarely poorly developed but frequently unequally so; body segments with regularly placed bristles, as shown in Figure 1, Plate XXVIII; head heavily chitinized, dorsally slightly areuate and with 2 longitudinal slits, ventrally slightly rounded and with a central slit; antennae longer than maxillary palpi; labium pointed, not divided into 2 plates, the anterior margin dentate; mandibles very stout, with only 2 teeth (at apex) in species without apical processes.....TIPULIDAE (p. 191).
- Apical abdominal segment with at most 5 radiating teeth, or if 6 are present the labium is subdivided centrally; body usually without regularly placed bristles, frequently with dense surface pilosity; head sometimes weakly chitinized and without distinct labium; antennae sometimes short and slender and not as long as maxillary lobe (not palpus); labium frequently subdivided into 2 plates; mandibles never with only 2 teeth.LIMNOBIIDAE (p. 207).
5. Thoracic segments fused and dilated, forming a complex mass.....CULICIDAE (p. 276).
- Thoracic segments not fused, distinct.....6
6. Larvae peripneustic, or with at least rudimentary abdominal spiracles .....
- Larvae amphipneustic or metapneustic.....12
7. Larvae with rudimentary abdominal spiracles; mouth with a large articulated process on each side which bears a number of long hairs and closes, fan-like, when at rest; posterior abdominal segments dilated, the last one armed on venter with a sucker-like disc which bears concentric series of bristles, by means of which the

larvae retain their hold upon rocks, etc., in the streams where they are found.....SIMULIIDAE (p. 302).

— Larvae with distinct though sometimes small abdominal spiracles; mouth without fan-like processes; posterior abdominal segments not noticeably dilated, the last without sucker-like disc; terrestrial species .....8

8. Antennae elongate; body armed with conspicuous bristles or hairs .....9

— Antennae usually short and inconspicuous, sometimes apparently absent; body without conspicuous bristles .....10

9. Anal spiracles at the apices of a pair of long stalk-like processes.....SCATOPSIIDAE (p. 300).

— Anal spiracles not noticeably elevated, situated near base of dorsal surface of apical segment.....BIBIONIDAE (p. 298).

10. Dorsal, or clypeal, sclerite of head not conspicuously tapered posteriorly; antennae well developed.....BOLITOPHILIDAE (p. 247).

— Dorsal, or clypeal, sclerite of head conspicuously tapered posteriorly; antennae almost indistinguishable .....11

11. Lateral sclerites of head meeting on ventral line only for a short space immediately caudad of mouth-opening, not connected at posterior margin.....MYCETOPHILIDAE (p. 248).

— Lateral sclerites of head connected for a very short space behind mouth-opening and again near posterior margin.....SCIARIIDAE (p. 258)

12. Dorsal surface of first and second abdominal segments each with 2 wart-like elevations somewhat resembling pseudopods, the apices of which are armed with numerous small hook-like setae; larvae aquatic, amphipneustic.....DIXIDAE (p. 279).

— Dorsal surface of first and second abdominal segments without elevated processes .....13

13. All or some of the dorsal segments with narrow, chitinized, strap-like transverse bands, or the apical segment in the form of a short chitinized tube; rarely the ventral abdominal segments bear a central series of sucker-like discs.....PSYCHODIDAE (p. 264).

— Dorsum without narrow, chitinized, strap-like bands, apical segment not in the form of a short chitinized tube; ventral abdominal segments never with sucker-like discs .....14

14. Apical abdominal segment with long, slender respiratory tube.....PTYCHOPTERIDAE (p. 238).

— Apical abdominal segment without long respiratory tube .....15

15. Antennae undeveloped, appearing as pale round spots on sides of head; ventral surface of head with the sclerites contiguous anteriorly, widely separated posteriorly .....16

— Antennae pedunculate, usually well developed; ventral surface of head with sclerite contiguous on entire length, not separated widely posteriorly .....17

16. Head subquadrate; abdominal segments with a number of rounded transverse ridges.....PLATYURIDAE (p. 260).  
 — Head elongate; abdominal segments without transverse ridges.....MYCETOPHILIDAE (p. 248).  
 17. Abdominal segments not subdivided.....18  
 — Abdominal segments subdivided by means of transverse constrictions.....19  
 18. Larva very slender, tapering towards the extremities, without thoracic or anal pseudopods or surface hairs except about 8 at apex of abdomen, aquatic in habit; or stout, with well-defined segments which are armed with strong bristles, some of which are lanceolate; pseudopods present; terrestrial, living in manure or under bark, etc.....CERATOPOGONIDAE (p. 281).  
 — Larva rarely very slender, generally of an almost uniform thickness, rarely with the thoracic segments appreciably swollen but not fused; abdominal and thoracic segments frequently with rather noticeable soft hairs, the last segment almost invariably with a conspicuous tuft of hairs on dorsum near apex; pseudopods almost always present, sometimes only the thoracic one distinguishable in terrestrial forms—which are very rare.....CHIRONOMIDAE (p. 284).  
 19. Body slender, tapering; abdominal segments each with a single constriction near anterior margin; apical segment either with 5 short terminal processes or without distinct processes.....RHYPHIDAE (p. 241).  
 — Body stout, of uniform diameter; abdominal segments each with 2 distinct constrictions; apical segment with 4 rather long processes, the lower pair longer than the upper..LIMNOBIIDAE, pt. (p. 207).

## PUPAE

1. Head with several strong thorns in a vertical series on the median line; pupae enclosed within galls on various parts of plants....CECIDOMYIIDAE, pt. (p. 293).  
 — Head without strong thorns, or if at base of each antenna there is a protuberance it is not sharp and thorn-like, and the pupae are not enclosed in galls on living plants.....2  
 2. Pupa enclosed within a tough, parchment-like envelope consisting of the hardened larval skin, which resembles a muscid puparium..CECIDOMYIIDAE, pt. (p. 293).  
 — Pupa free, or if enclosed it is within a cocoon which is not parchment-like and does not resemble a muscid puparium.....3  
 3. Thoracic respiratory organs sessile; abdomen without strong thorns or leaf-like elevations; legs straight.....4  
 — Thoracic respiratory organs stalk-like, or if sessile the abdomen has strong thorns or leaf-like elevations, or the legs are recurved against base of abdomen and apex of thorax, or the coxae do not

coneal the sternopleura and the scape of the antennae is almost globose; legs straight or recurved.....8

4. Legs short, apices of hind tarsi projecting slightly beyond apices of wings; antennae short, curved across middle of eye.....  
.....BIBIONIDAE (p. 298).

— Legs elongate, usually all tarsi projecting for a considerable distance beyond apices of wings; antennae elongate, extending to or beyond bases of wings.....5

5. Antennae almost straight, noticeably flattened, extending to bases of wings; thorax not much swollen in front, its anterior profile not declivitous.....PLATYURIDAE (p. 260).

— Antennae distinctly curved, not flattened, extending beyond bases of wings .....

6. Thorax conspicuously swollen, almost globose, its anterior profile declivitous; sternopleura concealed.....MYCETOPHILIDAE (p. 248).

— Thorax not conspicuously swollen, the anterior profile not declivitous.....7

7. Scape of antennae much swollen, globose; abdominal spiracles small or absent; sternopleura remarkably enlarged, not concealed by fore coxae and femora.....CHIRONOMIDAE (p. 284).

— Scape of antennae not much swollen; abdominal spiracles distinct; sternopleura not visible, concealed by the large coxae and femora of the fore legs.....CECIDOMYIIDAE, pt. (p. 293).  
.....SCIARIDAE, pt.....(p. 258).

8. Thoracic respiratory organs slender, long, and tube-like; legs straight, extending well beyond apices of wings; body without armature except a pair of hairs on anterior margin of head; sternopleura concealed.....CECIDOMYIIDAE, pt. (p. 293).  
.....SCIARIDAE, pt.....(p. 258).

— Species without the above combination of characters, abdomen usually with hairs or spines, or the sternopleura is exposed.....9

9. Pupa in a pocket- or slipper-shaped cocoon consisting of coarse threads, from the wide, open extremity of which project the thoracic respiratory organs, each of the latter consisting of 4 to 60 tube-like branches on a common base; rarely the cocoon is a mass of rather loose threads.....SIMULIIDAE (p. 302).

— Pupa free, or if enclosed or partly so the cocoon is not pocket-like and the respiratory organs do not consist of tube-like branches.10

10. Pupa when seen from above oval in outline, the abdomen at base not conspicuously narrower than thorax, so that the lateral outline is continuous; dorsal surface with very strong, almost chitinized, membrane.....11

— Pupa with the abdomen well differentiated from thorax, the dorsum membranous, or if strong and almost chitinized, then with surface spines.....12

11. Thoracic respiratory organs lamelliform, consisting of 4 flat plates, the broad sides of which are contiguous.....BLEPHAROCERIDAE (p. 274).
- Thoracic respiratory organs simple, tube-like.....PSYCHODIDAE, pt. (p. 264).
12. Apical abdominal segment terminating in 2 or 4 paddle- or fin-shaped organs which are fringed on all or a part of their outer surfaces with strap-like hairs; or if the apical segment terminates in 2 long subconical processes the tarsi are, as in the other group, recurved against the ventral surface of the base of abdomen and apex of thorax so that they do not extend beyond the apices of wings.....13
- Apical abdominal segment obtuse, armed with short or elongate spines or thorns, or if ending in a pair of long, slender processes these are more or less oval or circular in transverse section and without strap-like hairs; tarsi generally entirely straight, rarely the apices of the hind pair incurved slightly, but they are never recurved as above.....18
13. Thoracic respiratory organs terminating in numerous thread-like filaments.....CHIRONOMIDAE, pt. (p. 284).
- Thoracic respiratory organs consisting of a single stem, in some cases with a few long, or many short, scale-like surface hairs, but never terminating in numerous thread-like filaments; or occasionally the thoracic respiratory organs are not elevated.....14
14. Thoracic respiratory organs not elevated, sternopleura exposed.....CHIRONOMIDAE, pt. (p. 284).
- Thoracic respiratory organs conspicuously elevated.....15
15. Thoracic respiratory organs situated close to anterior margin of thorax; thorax and abdomen without stellate hairs.....CHIRONOMIDAE, pt. (p. 284).
- Thoracic respiratory organs situated close to middle of thoracic dorsum.....16
16. Apical abdominal segment ending in 2 or 4 broad, flat, paddle-like plates.....CULICIDAE, pt. (p. 276).
- Apical abdominal segment ending in 2 long subconical processes.....17
17. Apical processes armed at apices and on middle of their outer margin with short hairs (3:1).....CULICIDAE, pt. (p. 276).
- Apical processes unarmed.....DIXIDAE (p. 279).
18. Apices of legs not extending beyond apices of wings.....19
- Apices of posterior legs at least extending beyond apices of wings.....20
19. Apical abdominal segment ending in 2 conical processes.....CERATOPOGONIDAE (p. 281).
- Apical abdominal segment ending in 2 upper and 2 lower short thorns.....PSYCHODIDAE, pt. (p. 264).

20. Thoracic respiratory organs long, bifid; apical abdominal segment rounded, without processes; abdominal spiracles pedunculate..... SCATOPSIDAE (p. 300).

— Thoracic respiratory organs simple; apical abdominal segment not rounded, generally armed with protuberances..... 21

21. Thoracic respiratory organs elevated but little above the level of disc of thorax; tarsi of the fore legs overlapping those of mid pair, the latter overlapping those of hind pair, all rather closely fused together and to wings..... RHYPHIDAE (p. 241).

— Thoracic respiratory organs very conspicuously elevated; legs not as above ..... 22

22. Thoracic respiratory organs equal in length, rarely with one twice as long as the other; anterior, middle, and posterior tarsi distinct ..... 23

— Thoracic respiratory organs of conspicuously unequal length, one many times as long as the other; anterior tarsi overlapping middle pair..... PTYCHOPTERIDAE (p. 238).

23. Abdominal segments each with 1 transverse row, sometimes 2 such rows, of thorn-like protuberances; palpi recurved at apices..... TIPULIDAE (p. 191).

— Abdominal segments rarely with distinct thorn-like protuberances, usually with weak hairs; palpi straight, not recurved at apices.. LIMNOBIIDAE (p. 207).

## IMAGINES

1. Wing with at least 9 veins extending to the margin (exclusive of the anal vein); if there are only 8 such veins the radius is 3-branched, the second branch having its base proximad of the radio-medial cross-vein ..... 2

— Wing with less than 9 veins extending to the margin, or the venation not as above..... 8

2. Mesonotum with a more or less distinct V-shaped suture; male hypopygium generally very large, chitinous; female ovipositor conical, chitinized, and generally protruded..... 3

— Mesonotum without distinct suture, or if there is a poorly defined suture it is not V-shaped..... 5

3. Wing with 2 anal veins..... 4

— Wing with 1 anal vein..... PTYCHOPTERIDAE (p. 238).

4. Last palpal joint slender, much longer than the combined lengths of the 3 preceding joints; auxiliary vein terminating in first vein.... TIPULIDAE (p. 191).

— Last palpal joint at most but little longer than the combined lengths of the preceding joints; auxiliary vein usually terminating in costa, connected with first vein by a cross-vein..... LIMNOBIIDAE (p. 207).

5. Costa continued around the hind margin of the wing..... 6

— Costa discontinued at apex of wing..... RHYPHIDAE, pt. (p. 241).

6. Wing veins without conspicuous scale-like hairs. . DIXIDAE (p. 279).  
 — Wing veins with conspicuous scale-like hairs.....7

7. Wings short and broad, ovate, occasionally pointed apically; tibiae without apical spurs; small, robust species with rather short densely haired legs.....PSYCHODIDAE (p. 264).

— Wings elongate, narrow; tibiae with apical spurs; rather large, slender species, with long, slender, usually moderately hairy or scaly legs.....CULICIDAE (p. 276).

8. Wing with 2 to 4 distinct longitudinal veins.....CECIDOMYIIDAE (p. 293).

— Wing with 5 or more longitudinal veins.....9

9. Wings with a secondary reticulation of fine creases or lines in addition to the veins; slender tipulid-like species with long slender legs.....BLEPHAROCERIDAE (p. 274).

— Wings without a secondary reticulation of fine creases, at most with a longitudinal furcate crease between media and cubitus.....10

10. Abdomen in both sexes with a conspicuous flap-like scale at base of dorsal surface which is detached posteriorly and fringed with long hairs.....SIMULIIDAE (p. 302).

— Abdomen without such basal process.....11

11. Second basal cell of wing present.....12

— Second basal cell of wing absent.....13

12. Antenna consisting of 2 stout joints, and an apical arista-like one composed of 9 or 10 segments.....ORPHNNEPHILIDAE (p. 290).

— Antenna composed of 10-11 joints, the apical portion stout, not differentiated arista-like.....BIBIONIDAE (p. 298).

13. Antenna consisting of 10-11 joints in both sexes (10 if scape is regarded as consisting of 1 joint), the joints of central portion of flagellum shorter than broad; radius and costa conspicuous, the other veins indistinct; at least the mid and hind tibiae without apical spurs.....SCATOPSIDAE (p. 300).

— Without the above combination of characters.....14

14. Coxae unusually elongated.....15

— Coxae not unusually elongated.....19

15. Radius with 3 branches; medio-cubital cross-vein present.....16

— Radius with only 2 branches, or if there are three present the medio-cubital cross-vein is absent.....MYCETOPHILIDAE (p. 248).

16. Radio-medial cross-vein present, causing the base of the first posterior cell to be more or less broadly truncate.....17

— Radio-medial cross-vein apparently absent, fused with base of third branch of radius so that the base of first posterior cell is acute.18

17. Medio-cubital cross-vein much proximad of the radio-medial, causing the posterior portion, divided longitudinally by media, to be much shorter than the anterior portion. . BOLITOPHILIDAE (p. 247).

— Medio-cubital cross-vein almost directly in vertical line with the radio-medial, the 2 cells divided longitudinally by media subequal in length.....RHYPHIDAE, pt. (p. 241).

18. Antennae short, thick, and often flattened...PLATYURIDAE (p. 260).  
 — Antennae very long, usually exceeding in length that of body, very slender.....MACROCERIDAE (p. 260).  
 19. Mouth parts chitinized, constructed for piercing, not in the form of a long slender process.....CERATOPOGONIDAE (p. 281).  
 — Mouth parts not chitinized, fleshy, sometimes in the form of a long slender process .....20  
 20. Radius with 2 branches.....SCIARIDAE (p. 258).  
 — Radius with 3-4 branches, if less or indistinct the antennal joints with very long plumes in the male and very conspicuous constrictions between them in the female.....CHIRONOMIDAE (p. 284).

### Tribe POLYNEURA

I have included in this tribe, as I regard it, but one superfamily, Tipuloidea, containing the families Tipulidae, Limnobiidae, Ptychopoteridae, and Rhyphidae. Brauer limited his tribe Polyneura to Tipulidae (inclusive of Limnobiidae), placing the other two families in Eucephala.

I have placed this tribe first in my arrangement because I consider the adults much more primitive structurally than the most generalized forms in the other groups. The larvae undoubtedly show more specialization than do those of Mycetophiloidea both in the structure of the head, if we accept the capsule as the criterion, and in the respiratory system, but I find that the larvae of many closely allied species in different families show quite striking distinctions even though the adults are almost inseparable, and therefore have decided to consider the tribe as more generalized than the others. The sequence of families does not show an unbroken line, but, rather, represents a series of divergent lines of varying lengths, no two of which start from a common point.

### Superfamily *Tipuloidea*

#### SUPERFAMILY CHARACTERS

*Larva*.—Head incomplete posteriorly, wholly or partly retractile, or if the head is complete the abdomen has the anterior 6 segments subdivided, or the posterior respiratory tube is much elongated and membranous, and distinct paired ventral pseudopods are present on anterior half of body. Head with opposed mandibles; antennae well developed.

*Pupa*.—Head without conspicuous armature except in some Limnobiidae; antennae elongate, curved over upper margin of eyes. Wings and legs closely fused to thorax, the former very short, the latter never extending to apex of abdomen; thoracic respiratory

organs usually elevated, one of them much longer than the other in Ptychopteridae, the two normally of equal length and usually slender in Tipulidae, ear-like, appearing like vertical plates, in some Limno-biidae, while in Rhyphidae they are but little elevated and rather stout. Abdomen in Rhyphidae and most Tipulidae circular in cross-section, usually with 2 transverse series of more or less leaf-like or thorn-like protuberances on each segment.

*Imago*.—Distinguishable from all other Nematocera by the presence of the discal cell of wing. *Mycetobia* has no discal cell. This genus has been placed by most writers in the Mycetophiloidea, but lately its affinities with Rhyphidae have been considered closer, and Edwards traces in the presence of a well-defined gular plate a distinct connection with that family, this plate being almost invariably absent in Mycetophilidae, and even when present differing materially from that of *Mycetobia*. The venation of the *Mycetobia* wing differs from that of Mycetophilidae in that the second branch of the radius has its base proximad of the radio-medial cross-vein instead of distad of it. The female of *Mycetobia* has chitinized spermathecae, this character separating it from Mycetophiloidea, no genus of which possesses them. Some Tipulidae have no discal cell, but they all have a distinct V-shaped suture on the dorsum of the thorax—a character which distinguishes them from other Nematocera. Ptychopteridae possesses an incomplete V-shaped or slightly sinuous thoracic suture, and in common with related Nematocera, except Rhyphidae, has very long legs, slender wings, and a long slender body.

Allocation of species of the families must be arrived at by using the key to families of the Nematocera on a previous page.

#### Family *TIPULIDÆ*

This family as limited in the present paper contains only three subfamilies: Dolichopezinae, Ctenophorinae, and Tipulinae. Only the two last named are known to me in their immature stages. The number of species of Ctenophorinae in North America is small, but the genus *Tipula*, in Tipulinae, contains a very large number of species, the larvae, pupae, and imagines of which in very many cases bear a striking resemblance to each other. With the present collection it is not possible for me to do more than to indicate the principal characters useful in distinguishing the larvae and pupae from each other and from those of other families.

## FAMILY CHARACTERS

*Larva*.—Head heavily chitinized, retractile within prothorax; posterior portion deeply cleft longitudinally, one incision on each side of dorsum extending to, or almost to, middle, and one in center of venter extending beyond middle. Antennae elongate, consisting of an elevated base, an elongate joint—in *Tipula* at least four times, in *Xiphura* not more than twice, as long as broad—and a very short apical process. Front and clypeus fused, the former with a distinct plate on each side, the anterior margin of which is armed with a few bristles and many hairs; labrum fringed with hairs anteriorly; epipharynx with a number of spines or short processes. Maxillae well developed, fringed on the inner and anterior margins with hairs, and sometimes spinose; palpi small. Mandibles stout, the apex rounded and with 2 teeth more or less equal in size, lower margin with 2 or more teeth, inner upper margin with a fringe of hairs near middle. Labial plate (submentum) in the form of a flat plate, its outline medianly produced into an acute point anteriorly, the margin more or less distinctly dentate. Hypopharynx heavily chitinized, in the form of a flat plate the anterior margin of which is usually dentate, and with a posterior inverted-U-shaped chitinized piece which arches over the oesophageal opening. Body cylindrical; segments usually with distinct hairs which are situated on certain portions of each segment, their arrangement being uniform throughout the family; pseudopods present or absent; segments always with transverse linear depressions, most distinct on dorsum; apical segment with 6 processes, rarely without these being well developed; ventral surface of apical segment in aquatic and semiaquatic species with fringes of soft hairs on apical processes and with slender protrusive blood-gills; terrestrial forms with the fringes of hairs much reduced or absent, and the slender protrusive blood-gills usually absent, their function being performed by an irregular protrusive membranous organ.

*Pupa*.—The pupae differ from those of Limnobiidae in minor characters only, the principal distinction between them and pupae of the genus *Limnobia* and several other genera consisting in the form of the thoracic respiratory organs, those of Tipulidae, exclusive of Ctenophorinae, being long and slender, while those of the other family are stout and resemble a chitinized flattened plate. Many of the Limnobiidae, however, have slender thoracic respiratory organs, and other characters must be depended upon to distinguish them from Tipulidae. A brief summary of the characters of tipulid pupae is as follows: head without projecting chitinized armature; antennae

never swollen at bases; thoracic respiratory organs slender, of moderate length, sometimes slightly swollen at apices—except in Ctenophorinae, in which they are heavily chitinized, flattened, and highly glossy; legs exceeding the wings in length. Abdomen with 1 or 2 transverse series of short protuberances on each segment except basal and apical. Palpi recurved at apices.

*Imago.*—See synopsis of families.

#### HABITS OF LARVAE

Most of the larvae are scavengers, feeding on decaying vegetation, in mud containing vegetable debris, or in rotten wood. Occasionally some species of *Tipula* cause injury to crops such as oats and hay, or to pastures, by feeding upon the roots of the growing plants. Many of the species are aquatic or semiaquatic, living among floating vegetable matter along the margins of ponds or streams. The food consists of algae and various kinds of vegetable matter.

#### HABITS OF IMAGINES

The imagines occur commonly in damp situations, especially where there is a rank growth of vegetation. They feed upon nectar of flowers and upon moisture on vegetation and on the ground. Many of the species are readily attracted to lights.

#### KEYS TO SUBFAMILIES

##### LARVAE

1. Mandibles with 2 teeth; antennae about twice as long as broad..... *CTENOPHORINAE*.
- Mandibles with more than 3 teeth; antennae about 4 times as long as broad..... *TIPULINAE*.

##### PUPAE

1. Thoracic respiratory organs broad, glossy, and heavily chitinized (Pl. XXXII, Fig. 20)..... *CTENOPHORINAE*.
- Thoracic respiratory organs slender, opaque, not more heavily chitinized than dorsum of thorax..... *TIPULINAE*.

##### IMAGINES

1. Legs very long and slender, the tarsi especially so; anterior branch of second vein absent, indistinguishable, or perpendicular..... *DOLICHOPEZINAE*.

- Legs long but not very slender; anterior branch of second vein present, oblique ..... 2
- 2. Antennae of male pectinate or subpectinate. .... CTEPHORINAE.
- Antennae not pectinate. .... TIPULINAE.

### Subfamily CTEPHORINAE

I have before me only a part of a larval exuvium—consisting of the head—and the pupal exuvium of one species of this subfamily, and am consequently unable to give a detailed description of the immature stages. The specimens, however, present characters that serve to distinguish at least this species from other *Tipulidae* known to me. As the characters of the species I have may not be in agreement with those of other genera in the subfamily, unknown to me, I shall restrict my generalizations to the genus to which it belongs.

#### XIPHURA Brullé

##### GENERIC CHARACTERS

*Larva*.—Head large, heavily chitinized, arcuate on dorsum. Antennae short and stout, longer than maxillary palpi. Mandibles very stout, without teeth along the lower margin. Labial plate heavily chitinized, similar in general form to that of *Tipula*. Maxillae well developed, the palpi short and stout. Hypopharynx similar in form to that of *Tipula*. Structure of body not known to me. The parts of the exuvium that remain show that there are numerous long surface hairs present as in *Tipula*, and the anal spiracles are large, slightly elevated, pale brown, with the central opening darker.

*Pupa*.—Head without protuberances between antennae; bases of antennae slightly swollen; labium rather prominently protruded. Thoracic respiratory organs heavily chitinized, glossy, irregularly and coarsely wrinkled; apices of tarsi except those of the fore pair extending much beyond apices of wings. Abdomen with a single encircling series of short broad processes on each segment, the apices of which are acutely pointed.

##### HABITS OF LARVAE

All of the known larvae of this subfamily live in much-decayed trees, but whether they feed upon the dead wood or some vegetable growth it contains, or upon insect larvae is unrecorded.

## HABITS OF IMAGINES

The imagines feed upon nectar and sap. They are usually rare, and normally occur in proximity to a suitable larval habitat.

## XIPHURA FUMIPENNIS Osten Sacken

*Ctenophora fumipennis* Osten Sacken, Proe. Ent. Soc. Phila., 1864, p. 47.

*Larva*.—Head black, heavily chitinized, antenna short and stout, with a very short apical appendage (Pl. XXXII, Fig. 21); mandibles very robust, with 2 strong apical teeth (Fig. 25); labium dentate along its anterior margin, the central tooth simple; hypopharynx as in Figure 23, Plate XXXII, the anterior margin transverse.

*Pupa* (Pl. XXXII, Fig. 24).—Length, 22 mm. Dark brown, slightly shining. Thoracic respiratory organs glossy black. Abdominal spines dark castaneous at bases, becoming pale at apices.

Head without protuberances, the organs in the same positions and of the same form as in *Tipula*; antenna extending beyond base of wing. Thoracic respiratory organs robust, about twice as long as their greatest width, heavily chitinized, their margins irregular (Fig. 20). Abdomen with strong leaf-like process at apices of segments, the tips of which are very acute; lateral margin of segments with the same armature as in *Tipula*, one simple process before spiracles and another, bifid, behind them; spiracles small but distinct; apical segment elongated, its apical half consisting of 2 long upper, and 2 shorter lower, processes.

The foregoing descriptions were made from the larval and pupal exuvia of a female specimen reared by Dr. H. Glasgow, June 8, 1910. The larva was found in a much-decayed chestnut log in the Augerville woods, Urbana, Ill.

## Subfamily TIPULINAE

## SUBFAMILY CHARACTERS

*Larva*.—Head heavily chitinized; antennae longer than maxillary palpi; mandibles stout; labium well developed, usually dentate; hypopharynx large. Body without surface pilosity or with very short and dense pile; arrangement of bristles as shown in Figure 1, Plate XXVIII. Apical segment with 6 finger-like processes, sometimes of very unequal length; spiracles large.

*Pupa*.—Head usually with 2 small membranous protuberances above bases of antennae; antennae not swollen at base, and often with

a small thorn; palpi recurved at apices. Thorax with or without short wart-like protuberances on dorsum; respiratory organs long and slender; halteres visible above upper margin of wing and resembling in certain respects the posterior wings in some lepidopterous pupae; legs greatly exceeding length of wings. Abdomen with 1, or 2, transverse series of thorns on ventral segments beyond apices of legs, the anterior series, if both are present, much weaker than the posterior; dorsal segments usually with a postmarginal series of thorns.

#### HABITS OF LARVAE

As far as known the larvae are scavengers, feeding upon decaying vegetable matter. Many species are aquatic or subaquatic.

#### HABITS OF IMAGINES

The imagines fly most readily in the late afternoon. The species I have observed in nature are flower frequenters.

#### *TIPULA* Linné and *PACHYRRHINA* Macquart

As very few of the species before me have been reared, and are represented only by larvae or pupae or, at most, by both, there is at present no possibility of specifically identifying these immature stages. Neither is it possible for me to cite characters for the separation of the larvae of *Tipula* and *Pachyrrhina*, the reared material at hand being quite insufficient to justify any attempt at a generalization. I give a synopsis of the characters that appear to me to be of primary importance in the separation of the forms I have studied, but, unfortunately, I can specifically identify only a very few of them, and as in my opinion detailed descriptions would occupy more space than their possible scientific value will warrant me in taking, only the notes and synopsis are presented. I leave this subfamily in this condition, however, with the hope that the work now being done by C. P. Alexander on the biology of the crane-flies will satisfactorily fill the very large gap in our knowledge of the early stages of the group.

A complete study of our material is not at present contemplated, the forms described in this paper being included merely as indices to the range of specific distinctions, and as adjuncts to the synoptic characters cited in the key to the families.

#### KEYS TO SPECIES

##### LARVAE

1. Apical abdominal ventral segment with slender protrusive blood-gills.....

2

- Apical abdominal ventral segment with blood-gills in the form of an irregular protuberance, rarely acute laterally.....9
- 2. Ventral blood-gills not conspicuously longer than the stellate processes on margin of stigmatal field, these processes slender, regularly and very conspicuously fringed.....*Tipula* sp. 1.
- Ventral blood-gills conspicuously longer than stellate processes, or the latter not regularly and conspicuously fringed, or the processes very unequal in length.....3
- 3. Stellate processes subequal in length, very short, their margins with regular fringe of short hairs.....5
- Stellate processes very unequal in length, the upper two short, the lateral and lower ones much longer and with isolated groups of long hairs .....
- 4. Very large species, more than 40 mm. in length; penultimate abdominal segment with a lateral process.....*Tipula* sp. 2.
- Small species, 20 mm. in length; penultimate abdominal segment without a lateral process.....*Tipula* sp. 2a.
- 5. Small species, not more than 30 mm. in length.....6
- Larger species, more than 40 mm. in length.....7
- 6. Body with dense pubescence which is most conspicuous on 2 narrow longitudinal lines on dorsum, giving the species the appearance of being vittate; posterior latero-ventral bristles surrounded with stiff upright hairs.....*Tipula eluta*.
- Body without dense pubescent vittae; posterior latero-ventral bristles not surrounded with stiff upright hairs.*Tipula cunctans*.
- 7. Body almost regularly cylindrical, as in *eluta*; posterior latero-ventral bristles not on pseudopod-like elevations, their bases surrounded with short, stiff, upright hairs; dorsum not conspicuously vittate.....*Tipula* sp. 4.
- Body not regularly cylindrical, the segmentation deep, and the posterior segments with distinct pseudopod-like elevations; posterior latero-ventral bristles situated on elevations and not surrounded with stiff upright hairs; dorsum conspicuously vittate .....
- 8. The pale dorsal vittae composed of a number of closely placed pale dots; dorsum with many small pale paired spots; hairs not inserted in dark brown dots.....*Tipula abdominalis*.
- The pale dorsal vittae linear; dorsum with a number of very inconspicuous pale dots; hairs inserted in dark brown dots.*Tipula* sp. 3.
- 9. Apical abdominal segment with a conical protuberance on each side proximad of the processes on the margin of stigmatal field (Pl. XXXI, Figs. 6, 7).....*Tipula* sp. 6.
- Apical abdominal segment without a protuberance on sides.....10
- 10. Upper 4 processes on anal segment decurved, long, and pointed, much longer than lower pair, ventral respiratory organs acute laterally (Pl. XXXII, Figs. 7, 8); prothorax with 2 horny protuberances on its dorsal margin anteriorly.....*Tipula* sp. 5.

- Upper 4 processes on anal segment not decurved, usually straight; ventral respiratory organ not acute laterally; prothorax without horny protuberances on its dorsal margin anteriorly.....11
- 11. Upper median pair of processes on apical abdominal segment very acutely pointed, their posterior face glossy brown, lower pair very small and widely separated; hypopharynx with upper plate more acute than usual (Pl. XXXI, Fig. 14).....*Tipula* sp. 7.
- Upper median pair of processes on apical abdominal segment not acutely pointed, lower pair of moderate size and rather close together.....12
- 12. Upper plate of hypopharynx with acute teeth, its anterior outline distinctly convex (Pl. XXXII, Fig. 13).....*Tipula bicornis*.
- Upper plate of hypopharynx with rounded teeth, its anterior outline almost transverse (Pl. XXXII, Fig. 15).....*Pachyrrhina ferruginea*.

#### PUPAE

- 1. Thoracic respiratory organs very long and slender, one much longer than the other, the longest one at least half as long as entire body.....*Tipula* sp. 1.
- Thoracic respiratory organs equal in length, not more than one fourth as long as entire body.....2
- 2. Ventral abdominal segments beyond apiees of tarsi with a median and apical transverse series of spines.....3
- Ventral abdominal segments with only the apical series of spines.4
- 3. Antennae with a distinct but short thorn on outer side at base; frons slightly furcate and covered with irregular small wart-like protuberances between bases of antennae.....*Tipula cunctans*.
- Antennae without thorn at base; frons not as above...*Tipula eluta*.
- 4. No minute thorns or bristles laterad of the 2 strong thorns on third and fourth ventral abdominal segments; protuberance between base of antennae and base of thoracic respiratory organs small, forming a distinctly isolated wart-like prominence.....*Tipula trivittata*.
- One or two closely paired small thorns or 2 slender bristles laterad of the 2 strong thorns on third and fourth ventral abdominal segments; space between base of antennae and base of respiratory organs filled with a regularly rounded prominence.....5
- 5. Thoracic respiratory organs short, not extending more than half-way from their bases to medio-dorsal protuberances; 2 weak bristles laterad of the ventral series of thorns on abdominal segments; apical segment of female much elongated (Pl. XXVIII, Fig. 8).....*Tipula sert?*
- Thoracic respiratory organs long, extending almost or quite to medio-dorsal protuberances; one or two small thorns laterad of

the series of thorns on ventral abdominal segments; apical segment of female not elongate.....6

6. Apical abdominal segment drawn out into a long process consisting of an upper and a lower pair of tube-like organs (Pl. XXXII, Fig. 18).....*Tipula* sp. 7.

— Apical abdominal segment short and stout, not drawn out into a long process.....7

7. Apical segment with 4 small but distinct lobes at tip (Pl. XXVIII, Fig. 6).....*Pachyrrhina ferruginea*.

— Apical segment with 2 rather large lobes at tip (Pl. XXVIII, Fig. 7).....*Tipula bicornis*.

### TIPULA sp. 1

*Larva*.—Length, 20-22 mm. Dark brown, with an indistinct pale central vitta and slightly paler along sides.

Antennae about 4 times as long as their basal width, distinctly tapering apically; apical joint very small; frontal plate with a rather conspicuous tuft of hairs near outer anterior angle; labrum not conspicuously hairy; mandibles as in Figure 2, Plate XXXII; hypopharynx more elongate than in other species examined, its anterior margin with 3 rather large teeth in an almost transverse series and a much smaller one at angles (Pl. XXXII, Fig. 1); labium as in Figure 3, Plate XXXII. Body without surface pilosity; bristles very weak though long; latero-ventral bristle on posterior portion of each segment usually duplicated, sometimes triplicated; outer bristle of the transverse series on posterior portion of each of the dorsal segments duplicated; lateral bristles weaker than the dorsal and ventral series; apical segment as in Figure 8, Plate XXXI.

*Pupa* (Pl. XXVIII, Fig. 14).—Length of body, 15 mm.; that of longest respiratory organ, 9 mm. Dark brown, the lateral longitudinal elevation along the spiracular region pale; abdomen with dorsum indistinctly, and venter distinctly, bivittate.

Thoracic respiratory organs very slender, unequal in length, their apices flattened and split longitudinally; apices of fore tarsi falling short of apex of first abdominal segment beyond apices of wings, mid tarsi extending slightly beyond the apex of that segment, hind tarsi extending to middle of next segment. Exposed ventral abdominal segments, except apical, each with 2 series of thorns on posterior division, the anterior consisting of 2, widely separated, and the posterior of 4 to 14; no thorns on area covered by legs, and the next 2 series slightly interrupted at middle; apical segment with 4 long up-

wardly curved spine-like processes which are armed at apices with several short thorns.

The foregoing descriptions are made from a larva and pupa bearing the Laboratory accession number 26281, obtained by Dr. S. A. Forbes in Delavan Lake, Wis., May 25, 1892, taken in an inlet among weeds at the surface, and one larva, accession number 26282, taken by the same collector at the same place May 26, 1892.

The species is undoubtedly truly aquatic, judging from the structure of the apical segment. No means is at hand for associating the early stages with any described imago.

#### TIPULA sp. 2

*Larva* (Pl. XXVIII, Fig. 2).—Length, 45-55 mm. Brown, without well-defined vittae (alcoholic specimens).

General structure as in above-cited figure. The principal differences in head structure between this species and the preceding lie in the shape of the labium and the hypopharynx, the former (Pl. XXXII, Fig. 5) having a strongly produced central tooth and no distinct laterals, while the latter (Pl. XXXI, Fig. 13) has the anterior margin with only 2 weak protuberances and no rounded teeth; frontal plate as in Figure 9, Plate XXXI. Body without close pubescence, the armature as shown in Figure 2, Plate XXVIII; abdominal segments with the posterior lateral bristles on both dorsum and venter situated on pseudopod-like elevations; apical segment as in Figure 3, Plate XXVIII.

The foregoing description was made from alcoholic specimens in the Laboratory collection bearing the following data: Accession number 25756, Urbana, May 7, 1888, taken in woods (C. A. Hart); and two examples submitted by J. A. Hyslop (acc. 6687) from Hagerstown, Md.

#### TIPULA sp. 2a

This specimen may really be a young example of the foregoing, as it differs only in size (20 mm.) and in having a process on each side of the penultimate abdominal segment.

Locality, Blacktail Deer Creek, Yellowstone National Park, August 28, 1890; taken in an aquatic collection among vegetable debris (S. A. Forbes).

#### TIPULA ABDOMINALIS Say

*Ctenophora abdominalis* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 18. (1823)  
*Tipula abdominalis* Say, Needham, Bull. 47, N. Y. State Mus., p. 575. (1901)

A larva which was assumed to be of this species was described by Needham, as cited above. The markings given in that description appear to justify me in considering the species following as distinct from *abdominalis*.

TIPULA sp. 3

*Larva*.—Length when full-grown, 50 mm. Dark greenish brown, with 2 continuous moderately broad longitudinal vittae on dorsum, a dark brown median vitta, and a number of isolated pale dots; surface hairs set in small blackish or dark brown dots.

Head rather small in comparison with size of larva, lateral view as in Figure 4, Plate XXXII; antennae normal in size; labial plate (Pl. XXXII, Fig. 6) with one very large central tooth, with more or less distinct shoulders, and 3 smaller lateral teeth; hypopharynx (Pl. XXXI, Fig. 12) with anterior margin of upper plate slightly convex, the central tooth of the five the largest. Body similar in general structure to that of Species 2, but the apical segment very different, quite closely resembling that of Species 4 except that the ventral blood-gills are distinctly shorter and stouter.

Described from specimens obtained by Dr. S. A. Forbes in Black-tail Deer Creek, August 28, 1890, and in Slough Creek August 30, 1891—both in Yellowstone National Park.

TIPULA sp. 4

*Larva*.—Agrees in general appearance and armature of the abdominal segments with *eluta*, but differs in being much larger (50 mm.) and in having the apical abdominal radiating processes much less acute (Pl. XXXI, Fig. 5). The head agrees closely with that of Species 3, the labium (Pl. XXXII, Fig. 9) and hypopharynx (Pl. XXXI, Fig. 15) being of the same general structure, differing only in having the former narrower and more acute anteriorly; frontoclypeal region as in Figure 4, Plate XXXI; mandibles as in Figure 26, Plate XXXII.

Specimens are in our collection from Ithaca, N. Y. (March 21, 1897).

TIPULA sp. 5

*Larva* (Pl. XXIX, Fig. 3).—Length, 27 mm. Separable from other species that do not have the long slender blood-gills on apical abdominal segment by a pair of slight elevations or tubercles on the dorsum of the anterior third of the prothoracic segment, and by the peculiar formation of the apical segment, shown in Figures 7 and 8,

Plate XXXII. The hypopharynx and labium agree with those of *Pachyrrhina ferruginea*.

I have before me the specimen from which Mr. Hart drew up his description of his Species (b) in the paper on the "Entomology of the Illinois River and Adjacent Waters"\*, and a number of specimens sent in by a farmer October 7, 1915, from an alfalfa field at Towanda, Ill.

#### TIPULA sp. 6

This is the Species (a) described by C. A. Hart in his paper on Illinois River species. The apical segment differs from that of any allied species known to me, and this character alone should enable one to identify it. As Hart did not figure this species I have prepared drawings of the apical segment which are presented herewith (Pl. XXXI, Figs. 6, 7).

In addition to the specimen previously recorded from Havana, Ill., I have before me one taken in a sandy swamp at Grand Crossing, Ill., Nov. 7, 1891 (C. A. Hart).

#### TIPULA sp. 7

*Larva*.—Length, 25–30 mm. Brown, apical segment yellowish white on the posterior surface, the 4 upper radiating processes conspicuously blackened posteriorly, or on what is their inner or under surface when incurved, the lower pair with a black spot near apex which, because of the processes being normally curved upward, as in Figure 1, Plate XXXI, is not usually visible.

Head of normal size and shape, the dorsal and ventral surfaces as shown in Figures 2 and 3, Plate XXXI; hypopharynx as in Figures 11 and 14 of the same plate; mandibles as in Figure 27, Plate XXXII. Body with weak pilosity, the arrangement of bristles and the general structure as in *Pachyrrhina ferruginea*; apical segment differing as stated in key.

*Pupa*.—Length, 28–30 mm. Brown, slightly shining.

Base of antennae with a sharp thorn-like process on anterior side; a small rounded tubercle above and behind base of antennae. Thoracic respiratory organ about 10 times as long as its greatest width; postspiracular and medio-dorsal thoracic protuberances large, the latter sharp and not bifid, posterior protuberance small; legs ending just before apex of third abdominal segment, the apices of fore tarsi fall-

\*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, p. 217.

ing short of apices of mid pair. Two thorns on each side of third segment in line with apices of tarsi; 6 thorns on other segments, the lateral one of each series weakest; apical segment as in Figure 18, Plate XXXII.

This is the species described by C. A. Hart as Species (c) in the paper previously referred to. It occurs in humid earth and especially under logs or leaves. In addition to Hart's material I have before me two specimens from St. Clair Co., Ill. (Nov. 26, 1886).

#### TIPULA ELUTA Loew

*Tipula eluta* Loew, Bull. Ent. Zeitschr., 1863, p. 290.

The external characters of this species have been very fully described by C. A. Hart in his paper on the "Entomology of the Illinois River and Adjacent Waters"\*. The details given here are merely supplementary.

*Larva* (Pl. XXIX, Fig. 1).—Antennae about 4 times as long as basal width, slightly tapering apically; maxillary palpi longer than broad; labial plate with a large rounded central tooth, and 2 much smaller lateral teeth and 2 poorly developed protuberances on each side; hypopharynx similar to that of Species 4 (Pl. XXXI, Fig. 15). Lateral abdominal bristles as shown in Figure 1, Plate XXVIII.

*Pupa* (Pl. XXIX, Fig. 2).—Thorax with the postspiracular, medio-dorsal, and postero-dorsal protuberances small but distinct. Legs in female extending to apex of first abdominal segment beyond apices of wings, in male to middle of the next segment. Armature of ventral abdominal segments similar to that of Species 1 except that the second visible segment has the widely separated anterior pair of thorns reduced to mere hairs, and the other segments have these same thorns simple, with a small hair at base instead of 2 thorns as in that species; apical segment of sexes as in Figures 11, and 13, Plate XXVIII.

These descriptions and the figures are made from specimens used by Mr. Hart as a basis for his descriptions of *eluta* in the paper above referred to. The specimens were obtained from the Illinois River at and near Havana, Ill. The larva is usually found burrowing in the sand on the shore, but occasionally is found in the water. I have taken the larvae from wet mud and sand along the margin of a small stream at Muncie, Ill., and very probably the species occurs in similar situations throughout the state.

\*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art VI, pp. 212-214. (1895)

## TIPULA CUNCTANS Say

*Tipula cunctans* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 23. (1823)

*Larva*.—Similar to the previous species in general appearance and structure, the principal distinctions being as follows: the frontoclypeal region is less hairy, the plates on either side having only an isolated tuft of hairs at outer anterior angle and one bristle and a short thorn on inner anterior protuberant area; the labial plate (Pl. XXXII, Fig. 10) has 3 large teeth on each side of the central one; anterior outline of hypopharynx as in Figure 11 of same plate; the body is not densely pubescent, and shows no vittae on dorsum; and the short, stiff, upright hairs that surround the bristles in *cluta* are wanting.

*Pupa*.—Length, 18–22 mm. Reddish brown, lateral margins yellowish.

Slenderer than *cluta*. Head rather distinctly protuberant between antennae, the surface with coarse rugae and a few small warts; bases of antennae with a small sharp process on anterior surface. Area between base of antennae and respiratory organs regularly rounded; dorsum of thorax without the distinct protuberances so noticeable in *cluta*; apices of fore, mid, and hind tarsi not in a transverse line, but each successively farther beyond apices of wings. All of the exposed abdominal segments with 2 series of spines each, the anterior one consisting of 2, widely separated, and the posterior series of 4–12, closely placed; the third and fourth segments have the anterior pair of spines reduced to mere hairs; dorsal segments with only the posterior armature distinct; apical segment of female as in Figure 19, Plate XXXII, that of male as in Figure 22.

Described from examples in the collection obtained at Newton and Hillsboro, Ill., April 1896. The species is very common throughout the state and, like *T. bicornis*, is sometimes destructive in meadows, pastures, and other grass lands, the larvae feeding on the roots of the plants.

This species is usually found in quite different surroundings from those of *cluta*, being essentially terrestrial in habit and often found in fields which are rather dry and well removed from any body of water.

## TIPULA TRIVITTATA Say

*Tipula trivittata* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 26. (1823)

*Pupa*.—Length, 22–25 mm. Dark brown, lateral line pale.

Bases of antennae with a sharp protuberance on anterior side; a

small but distinct elevated tubercle immediately behind antennal base. The usual 6 small elevations on dorsum of thorax, the medio-dorsal pair duplicated transversely; wings extending to apex of second abdominal segment; legs extending beyond apex of third, terminating in a straight transverse line. All dorsal segments except apical one with a transverse series of thorns on or near posterior margin, the series becoming successively stronger from basal segment to apical; postnotum with 4 very small protuberances; third and fourth ventral abdominal segments each with 2 widely separated thorns, fifth to eighth inclusive with 4 each; prespiracular and postspiracular spines of equal strength, both simple; apical segments of male and female as in Figures 16, and 17, Plate XXXII.

The foregoing description was made from exuvia supplied by Dr. E. P. Felt and J. A. Hyslop, the former obtaining his specimens at Albany, N. Y., May 5, 1909, and the latter obtaining his at Wolfville, Md., May 21, 1915. The species is represented in the Laboratory collections by two imagines from Algonquin, Ill.

#### TIPULA SERTA Loew?

*Tipula sarta* Loew, Berl. Ent. Zeitschr., 1863, p. 283.

*Pupa*.—Length, 30 mm. Yellowish brown. Robust. Head with a pair of small rounded elevations above and between bases of antennae; antennae without a distinct basal process. Thoracic respiratory organs less than 6 times as long as their greatest width; postspiracular protuberances in the form of rounded elevations; mediadorsal pair carinated, simple; tarsi terminating in a straight transverse line at apex of third abdominal segment. Armature of ventral abdominal segments confined to posterior margins, that of third and fourth segments consisting of 2 thorns, that of remaining segments of 4; laterad of the thorns on each segment are 2 slender bristles; apical segment much elongated (Pl. XXVIII, Fig. 8).

The foregoing description was made from the pupal exuvium of a female that was reared from a larva found by the writer under a log at White Heath, Ill., in March, 1916 (Acc. No. 46302).

Owing to the great uncertainty in identifying species of this genus from descriptions, the above name should be regarded as a tentative one.

#### TIPULA BICORNIS Forbes

*Tipula bicornis* Forbes, 16th Rep. State Ent. Ill., p. 78. (1888)

This species was originally described by Dr. Forbes, as above

cited, the description of the imago being given on page 80. The species stands in the Loew collection at Cambridge, Mass., under the name *bicornis* Loew, but never was described by Loew.

Mr. Hart, in his "Entomology of the Illinois River and Adjacent Waters" unfortunately entered in his key the larva of *cunctans* as that of *bicornis*.

The larva of *bicornis* is almost inseparable by superficial characters from that of *Pachyrrhina ferruginea*, but possibly with better and more material than I have, such separation may be feasible. In examples which I have dissected I find that the labial plate and hypopharynx furnish characters that appear to be of specific value. These differences are shown in Figures 12 and 13, and 14 and 15, Plate XXXII.

The pupae of the two species are also very similar in structure, and I find in the shape of the apical segment of the females the only appreciable distinction. This difference is illustrated by Figures 5 and 7, Plate XXVIII. The apical segment of the male pupa may provide characters for the separation of this sex also; I have no male pupa of *bicornis* for examination.

The species is very widely distributed in this state, and is sometimes destructive to pastures, the larvae feeding on the roots of the grasses.

#### PACHYRRHINA FERRUGINEA Fabricius

*Tipula ferruginea* Fabricius, Sept. Antl., Species 28. (1805)

The larva (Pl. XXVIII, Fig. 4) of this species bears a striking resemblance to *T. bicornis* and is found in the same situations. I have no well-preserved specimens of authenticated *bicornis* for comparison of the external characters with those of *ferruginea*. The frontal plate is as in Figure 10, Plate XXXI, and dissection of the head shows the distinctions mentioned under *bicornis* (see Pl. XXXII, Figs. 14, 15). Apical abdominal segment as in Figure 3, Plate XXX.

The pupa is also very similar to that of *bicornis*, the only characters that appear to be useful in their separation being found in the apical abdominal segment—as stated in key. (See Pl. XXVIII, Figs. 5, 10, 12.)

The species is common and widely distributed in Illinois.

#### PRINCIPAL PAPERS ON NORTH AMERICAN TIPULIDAE

Hart, C. A.

- '95. On the entomology of the Illinois River and adjacent waters. Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI.

Needham, J. G.

'07. Report of the entomologic field station conducted at Old Forge, N. Y., in the summer of 1905. Bull. N. Y. State Mus., No. 124: 199-248.

Needham, J. G., and Betten, C.

'01. Aquatic insects in the Adirondacks. Bull. 47, N. Y. State Mus.

Osten Sacken, C. R.

'69. The North American Tipulidae. Monographs of North American Diptera, Part 4. (A list of additions and corrections appears at end of Part 3, which was published after Part 4.)

### Family LIMNOBIIDAE

This family is of much greater extent than Tipulidae and contains a much larger number of genera, none of which in their larval and pupal stages—judging from the data at hand—show the same uniformity that is found in the genera *Tipula* and *Pachyrrhina*. It is difficult to separate the larvae and pupae of the two families, but I believe that the following summary of characters will serve this purpose.

#### FAMILY CHARACTERS

*Larva*.—Head in all subfamilies but Trichocerinae, Hexatominae, and Eriopterinae very similar to that of Tipulidae except that the antennae are much more slender, and frequently they are shorter than the maxillary palpi. The labial plate is often divided longitudinally in the center, each part being furnished with distinct teeth, while in all Tipulidae known to me the labial plate is entire and subtriangular, with a single apical tooth and usually several laterals. In Hexatominae and some Eriopterinae that I have examined the labium is not chitinized, and posteriorly the head is composed of 4 or 6 slender chitinized rods connected by weakly chitinized membrane. In Trichocerinae the head is complete, and the prothoracic spiracles are present. The mandibles in the species with tipulid-like head are much more slender than in Tipulidae, and in the latter when the apical segment has no protuberances the mandibles are very stout and have but 2 teeth, both at apex. The apical segment in Limnobiidae is very differently constructed in the different genera, but as far as I have seen there are never 6 processes, which in Tipulidae is the almost invariable number.

*Pupa*.—The pupae of all genera of this family known to me may be readily separated from those of Tipulidae by the straight palpi, since those organs in Tipulidae have their apices recurved.

## HABITS OF LARVAE

The larvae have more diversified food-habits and habitats than do those of *Tipulidae*. A summary of these is given under the different genera dealt with in the text.

## HABITS OF IMAGINES

The food of the imagines, when any is taken, usually consists of nectar.

## KEYS TO SUBFAMILIES

## LARVAE

1. Thorax and abdomen with numerous long fleshy appendages.....  
.....  
.....*CYLINDROTROMINAE* (p. 210).
- Thorax and abdomen without long fleshy appendages.....2
2. Labium not chitinized; mandibles long and sickle-shaped, toothed only on basal half; maxillae with a very long membranous lobe at anterior lateral angle; apical segment with 4 processes, which are fringed with long hairs; penultimate segment in preserved larvae much distended.....*HEXATOMINAE* (p. 232).
- Labium heavily chitinized except in *Eriopterinae*; mandibles stout, toothed on apical half; and otherwise not as above.....3
3. Apical abdominal segment terminating in a pair of long tail-like appendages, the spiracles at their bases, above; labial plate divided in center.....*PEDICINAE* (p. 216).
- Apical abdominal segment terminating in 4 or 5 short protuberances, or at least not with 2 long terminal appendages.....4
4. Apical abdominal segment with 5 short terminal protuberances, the central one on upper margin about as large as the others; body usually pubescent or roughened; head posteriorly consisting of 6 slender rods.....*ERIOPTERINAE* (p. 227).
- Apical abdominal segment with 4 terminal protuberances or without any, or if there are 5 the central one on upper margin is much smaller than the others and the head is not as above.....5
5. Head complete; prothoracic spiracles present.....  
.....  
.....*TRICHOCERINAE* (p. 234).
- Head incomplete posteriorly; prothoracic spiracles absent.....6
6. Body green, with dense groups of fuscous hairs on dorsum of segments, which give it the appearance of being marked with black.....  
.....*LIMNOBIINAE*, pt. (p. 212).
- Body yellowish, whitish, or brownish, without distinct groups of hairs as above.....  
.....  
.....7
7. Segments broader than long, lateral margins of prothorax with 1 strong hair, those of the other segments with 2 such hairs.....  
.....*RHAMPHIDIINAE* (p. 226).

- Segments at least as long as broad, lateral margins without strong hairs.....8
- 8. Body covered with short decumbent hairs, or, if bare, without narrow stripe-like locomotor areas; apical segment with 4 or 5 processes.....*LIMNOPHILINAE* (p. 220).
- Body without decumbent hairs; locomotor organs consisting of narrow transverse strips on dorsum and venter which are slightly leathery and armed with short spinules.....*LIMNOBIINAE*, pt. (p. 212).

## PUPAE

- 1. Thoracic respiratory organs very short and stout, not more than twice as long as their greatest breadth; armature of abdominal segments weak, the same on dorsum and venter, consisting of a single narrow, chitinized or setigerous, band.....2
- Thoracic respiratory organs very much elongated, usually more than 6 times as long as their greatest breadth or they are knobbed at apices; or abdominal armature usually strong, thorn-like or spinose, or not in the form of bands.....3
- 2. Thoracic respiratory organs well separated basally.....*LIMNOBIINAE*, (p. 212).
- Thoracic respiratory organs subcontiguous basally.....*RHAMPHIDIINAE* (p. 226).
- 3. A pair of large leaf-like projections above bases of antennae.....*HEXATOMINAE* (p. 232).
- No leaf-like projections above bases of antennae.....4
- 4. Abdominal segments each with 2 or more very long thorn-like projections on posterior margin, which are in some species armed with small branches; rarely these projections are confined to apical 2 segments.....*CYLINDROMINAE* (p. 210).
- Abdominal segments each with small spines, or if rather large projections are present they are short and leaf-like, rather numerous, and unbranched.....5
- 5. Thoracic respiratory organs stout, knobbed at apices.....*PEDICINAE* (p. 216).
- Thoracic respiratory organs slender, not knobbed at apices.....6
- 6. Thoracic respiratory organs not slender and tube-like, flattened and but little elevated.....*ERIOPTERINAE*, pt. (p. 227).
- Thoracic respiratory organs long and usually tube-like, much elevated.....7
- 7. Abdomen without dorsal or ventral armature; thoracic respiratory organs not longer than width of thorax, slender and tube-like.....*ERIOPTERINAE*, pt. (p. 227).
- Abdomen either with distinct armature on apices of dorsal segments or on both dorsal and ventral ones and with the thoracic respira-

tory organs longer than width of thorax; or if the armature of abdomen is very weak the thoracic respiratory organs are not tube-like but acute apically..... *LIMNOPHILINAE\** (p. 220).

#### IMAGINES

1. Only one submarginal wing-cell present.....	2
— Two submarginal wing-cells present.....	4
2. Antennae with 14 segments.....	<i>LIMNOBIINAE.</i>
— Antennae with 16 segments.....	3
3. Tibial spurs present.....	<i>CYLINDROTOMINAE.</i>
— Tibial spurs absent.....	<i>RHAMPHIDIINAE</i>
4. Tibial spurs absent.....	<i>ERIOPTERINAE.</i>
— Tibial spurs present.....	5
5. Subcostal cross-vein proximad of base of second vein.....	<i>PEDICINAE.</i>
— Subcostal cross-vein distad of base of second vein.....	6
6. Antennae with 16 or more segments.....	7
— Antennae with at most 10 segments.....	<i>HEXATOMINAE.</i>
7. Seventh vein short, abruptly deflected towards anal angle.....	<i>TRICHOCERINAE.</i>
— Seventh vein normal, not deflected towards anal angle.....	<i>LIMNOPHILINAE</i>

#### Subfamily CYLINDROTOMINAE

This subfamily includes but four genera, each containing from one to four or five species, and because of the peculiar anatomical characters of the different stages it may yet be considered as entitled to separate family rank. I have treated the subfamily in this paper as belonging to Limnobiidae.

#### SUBFAMILY CHARACTERS

*Larva.*—Head similar to that of Tipulidae, the dorsal surface arcuate, heavily chitinized, and with 2 slits which usually extend proximad of the middle. Antennae slender, longer than maxillary palpi. Mandibles stout, with a strong apical tooth, and several smaller teeth along the lower margin. Labial plate similar to that of Tipulidae, the central tooth simple or bifid. Thoracic and abdominal segments with long fleshy spine-like processes which may be either simple or more or less furcate. Apical segment with 4 slender processes; spiracles rather small.

*Pupa.*—Head without projections; antennae curved over eyes. Thorax very short; respiratory organs long and slender; wings ex-

\*I do not know what characters may serve to separate pupae of Limnophilinae and Triehocerinae.

tending to apex of second abdominal segment; legs, to or nearly to apex of third. Abdominal segments more or less distinctly subdivided by transverse incisions; dorsum of all segments or of the apical 2 with long thorn-like processes; lateral margins with short thorn-like protuberances.

*Imago*.—See key to subfamilies.

#### HABITS OF LARVAE

The larvae of this subfamily feed upon living plants, and are, as far as I know, the only species of Tipuloidea that have this food-habit. They also differ from all other Tipuloidea except *Dicranomyia* in being green. It is very difficult to detect them upon their food plants, which consist of living mosses, or, in the case of *Cylindrotoma*, of *Viola*, *Stellaria*, and *Anemone*. *Phalacroccra* feeds upon submerged aquatic mosses. The larvae are very sluggish.

#### HABITS OF IMAGINES

The flies are rather sluggish, and may be swept from plants on which the larvae have fed or from those along the margins of streams or ponds.

#### KEYS TO GENERA

##### LARVAE

1. Thoracic and abdominal processes long and slender, the posterior submedian pair on each abdominal segment furcate near bases; aquatic or semiaquatic species (Pl. XXXIII, Fig. 1).....  
..... *Phalacroccra*.
- Thoracic and abdominal processes short and leaf-like, not furcate near bases, at most with short protuberances.....2
2. Dorsal processes simple..... *Cylindrotoma*.
- Dorsal processes with short protuberances anteriorly.....3
3. Some of the dorsal processes with 4 short protuberances on their anterior surface..... *Triogma*.
- None of the dorsal processes with more than 2 protuberances on their anterior surface..... *Liogma*.

##### PUPAE

1. Only the apical 2 abdominal segments with long, rather slender protuberances (Pl. XXXIII, Fig. 4)..... *Phalacroccra*.
- All abdominal segments with long, slender protuberances.. *Liogma*.

## Subfamily LIMNOBIINAE

I have before me the larva of one species, and the pupal exuvia of two species, of *Limnobia*, and the larva and pupa of one species of *Dicranomyia*.

## SUBFAMILY CHARACTERS

*Larva*.—Head well developed, moderately chitinized. Posterior dorsal slits extending proximad of middle; antennae elongate, base elevated, first joint more than twice as long as broad; maxillary palpi much shorter than antennae, 2-jointed; labial plate well developed, dentate along its anterior margin; mandibles stout, with one or two large apical teeth, and a series of smaller teeth along their lower margin on its apical half. Thorax and abdomen without pseudopods, the locomotor organs consisting of a narrow transverse strip of weak hairs or spinules on the dorsal and ventral surfaces of some or all of the segments; in *Dicranomyia* these locomotor spinules are little stronger than the others on dorsum. Apical segment without finger-like processes; the spiracles in terrestrial forms not in a pronounced depression but capable of being enclosed by the infolding of the apex of the segment; the spiracles in aquatic forms situated in a cleft, with hair-fringed margins, in apex; both terrestrial and aquatic forms with short protrusive blood-gills.

*Pupa*.—Head without protuberances. Thoracic respiratory organs very broad, their length not exceeding their greatest width; legs much longer than wings. Abdomen with locomotor organs similar to those of larva.

*Imago*.—See key to subfamilies.

## HABITS OF LARVAE

The larvae of *Limnobia* are fungivorous and terrestrial; those of *Dicranomyia* feed on algae and are aquatic or semiaquatic. A glutinous tube is made by the larvae of both genera when nearly or quite mature, and in this pupation takes place.

## HABITS OF IMAGINES

The species of *Limnobia* usually occur in dense woods where fungi are common; those of *Dicranomyia* occur near bodies of water. The species of *Geranomyia* frequent flowers, as do the adults of some of the other genera.

## KEYS TO GENERA

## LARVAE

1. Apical abdominal segment appearing cleft, the margins of the cleavage fringed with hairs; body with close pubescence; apical ventral blood-gills slender, pointed..... *Dicranomyia simulans*.
- Apical abdominal segment rounded or slightly truncate, not cleft, and without hairs; body not pubescent; apical ventral blood-gills stout, rounded..... *Limnobia*.

## PUPAE

1. Thoracic respiratory organs broad, subquadrate, their apices truncate, the bases with a hook-like protuberance..... *Dicranomyia simulans*.
- Thoracic respiratory organs rounded, ear-like, without any hook-like protuberances at base..... *Limnobia*.

## DICRANOMYIA SIMULANS Walker

*Limnobia simulans* Walker, List of Diptera in British Museum Coll., Pt. I (1848), p. 45. Imago.

*Dicranomyia simulans* (Walker) Needham, 23d Rep. State Ent. N. Y., p. 214. (1907)

*Larva*.—Length, 11-13 mm. Green, with distinct fuscous marks on dorsum which are broken up by small round clear spots and irregular clear patches. A close examination discloses the fact that the fuscous areas are composed of closely placed spinose hairs, while the clear spots are either devoid of hairs or yellowish hairs are present.

Head large, similar in general appearance to that of *Limnobia*; antennae long, the shaft about 3 times as long as its greatest diameter; maxillary palpi short and inconspicuous; labium slightly convex in outline, central tooth much longer and stouter than the first lateral, second and third laterals as large as central. Thoracic and abdominal segments each with distinct anterior marginal fusiform area, these areas not armed with distinct spinules; incisions between dorsal segments of abdomen marginated with blackish spinules which are appreciably, but not much, stronger than the hairs on the fuscous dorsal markings; apical segment with a cleft appearance, the aperture closing, mouth-like, with the lips vertical.

*Pupa*.—Length, 8-9 mm. More fuscous than the larva.

Thoracic respiratory organs as in Figure 5, Plate XXXIII, their structure separating them from any other genus known to me. My only specimen is in a fragmentary condition, which prevents me from

giving a detailed description.

Described from materials obtained by D. K. McMillan at Lake Forest, Ill., November 29, 1916.

The larva and pupa of this species were described by Needham from this same locality, where they are abundant among algae on the piers, just above and below the surface of the water.

LIMNOBIA Meigen

GENERIC CHARACTERS

*Larva*.—Head broad, the exposed portion, except for the labrum, subquadrate; antennae of moderate length, 2-jointed; mandibles rather large. Body consisting of 12 segments; dorsal and ventral surfaces with some or all of the segments individually armed with a transverse band of setulae, those on ventral segments situated upon more or less raised transverse ridges or swellings; apical segment with 2 large, rounded spiracles, without well-defined tubercles, anal ventral blood-gills short, consisting of a pair on each side.

*Pupa*.—Head unarmed. Thoracic respiratory organs in the form of a large disc-like chitinized plate which is attached, ear-like, to anterior lateral angle of thorax; legs elongated, the hind pair covered almost to apex of basal tarsal joint by the wings, so that only 2 pairs are visible for this distance, apices of tarsi almost in a straight line; wings ending at apices of basal tarsal joints. Armature of abdominal segments similar to that of larva except that the apical segment is slightly chitinized and more or less tuberculate.

I can not describe the position of the legs in either of the species before me as only exuvia are available. The figure of *immatura* is made from a cast pupal skin, and details of the venter of the thorax are incomplete. The spiracles on the abdomen are not well defined, the normal chitinized margin of the openings, so evident in many groups, being absent. In the specimens before me there are, however, two spiracles with distinct chitinized rims on the dorsum of the eighth segment which are connected with stout tracheae. In the specimen of *immatura* the main tracheae are still visible and each is connected with the integument on the lateral margin of the segments. The apices of the lateral branches appear to connect, by means of a compact mass of thread-like branches, with the wall of the abdomen, and have no distinguishable external aperture. Without a larger amount of material for study I can not definitely state whether these lateral tracheae are functional or not.

## HABITS OF LARVAE

The only species that I have reared was found feeding in fungi (*Agaricus* sp.). The species are recorded as fungivorous. Before pupation the larva forms a glutinous tube which is very compact, and in this the pupa is enclosed. The pupa of *immatura* was found under a bush in woods near Urbana, the larva having very probably fed upon some fungus there.

## HABITS OF IMAGINES

The imagines of many species of this genus are found commonly in woods, flying among the low herbage, and are also frequently taken feeding on nectar of various plants.

## LIMNOBIA TRIOCELLATA Osten Sacken

*Limnobia triocellata* Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 216.

*Larva* (Pl. XXXIII, Fig. 13).—Length, 18–20 mm. White, semitransparent (alcoholic specimens). Dorsum of head with a large blackish patch on each side. Head as in Figures 16 and 17; mandibles as in Figure 6; antennae of moderate length, distinctly 2-jointed. Thoracic segments 2 and 3 each with a large number of transverse series of minute spinules on anterior fifth of dorsal surface; first segment with a few microscopic hairs rather longer than the spinules on segments 1 and 2; ventral surface of the three segments with very similar armature, that on 2 and 3 the more compact, rather longer, and with the areas occupied by it slightly elevated. Abdominal segments 1–7 each with a narrow transverse stripe of short black spinules on posterior margin, the stripes tapering to a point on each side and not reaching lateral margin except in the case of the one on segment 7, which is broad and connects with a similar band or stripe on ventral surface; anterior margins of all segments of venter with a transverse swelling which is armed with stiff black spinules similar to but rather longer than those on dorsal surface, these spinules and those of the dorsal series, without magnification, giving the larva the appearance of having 7 narrow black dorsal stripes and 10 broader ventral ones; apical segment with the large rounded spiracles situated in a slight cavity, the margins of which are slightly irregular but not furnished with well-defined tubercles, the spiracles being capable of entire enclosure by the retraction of the central cavity and the infolding of the margin; apical ventral surface with a pair of short, rounded, retractile blood-gills (Fig. 10).

*Pupa*.—Length, 12-15 mm. Pale yellowish testaceous; head, thorax, and base and apex of abdomen pale brown, slightly shining. Head without armature, front view as in Figure 2, Plate XXXIV. Thoracic respiratory organs reddish brown, similar to those of *immatura*; wings and legs as described for this genus. Abdominal segments 3-8 each with a conspicuous transverse band of short setulae on anterior margins of both dorsal and ventral surfaces, the bands not connected on lateral margins; the 2 basal ventral bands widely interrupted below legs, the apical one also interrupted, the others complete; abdomen without distinct spiracles except a pair on dorsum at base of apical segment which are connected with stout tracheae; apical segment as in Figures 3 and 4, Plate XXXIV, basal 3 segments and the penultimate dorsally slightly brownish yellow, probably owing to the presence of chitin; apical segment almost entirely brownish yellow.

Described from larvae and from pupal exuvia of specimens obtained by the writer from a species of fungus (*Agaricus*) in the forestry of the University of Illinois, at Urbana, in September, 1915.

#### LIMNOBIA IMMATURA Osten Sacken

*Limnobia immatura* Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 215.

*Pupa* (Pl. XXXIII, Fig. 11).—Length, 20 mm. Color as in preceding species. Differs from it in size, in the structure of the respiratory organs (Pl. XXXIII, Fig. 14), and in that the median interruption of the setulose band is on the seventh ventral segment. There is also a slight but distinct difference in the structure of the front of the head, as shown in Figures 1 and 2 of Plate XXXIV; but this may be due to the different sex of the specimens—which in large measure accounts for a difference in the structure of the apical abdominal segments of the specimens (Pl. XXXIII, Figs. 11, 12).

Described from pupal exuvium of a female. The pupa was found near a bush in Cottonwood Grove, about four miles east of Urbana, Ill., March 23, 1911, and emerged four days later (C. C. Dillon).

#### Subfamily PEDICIINAE

With the exception of the larvae of two species, I have no materials representing this subfamily, and depend upon the published description of *Dicranota* by Miall and of *Pedicia* by Beling for characters of the pupae.

## SUBFAMILY CHARACTERS

*Larva*.—Head well developed, the dorsum chitinized and with 2 elongate posterior excisions; labium well developed, in some genera (*Pedicia* and *Dicranota*) in the form of 2 plates; mandibles stout, their inner lower margin toothed. Some of the abdominal segments with conspicuous locomotor organs, either in the form of paired pseudopods or elevated transverse areas. Apical segment with 2 long terminal processes. Spiracles situated on dorsum at base of terminal processes.

*Pupa*.—Distinguishable from allied forms by the knobbed respiratory organs. The ventral segments of the species described by Miall each have a pair of tubercles on the disc, but Beling's description of the pupa of *Pedicia rivosa* makes no mention of such tubercles.

*Imago*.—See key to subfamilies.

## HABITS OF LARVAE

The larvae are aquatic, feeding upon algae and small Crustacea of various kinds, or upon aquatic worms.

## HABITS OF IMAGINES

The imagines are of a rather sluggish habit, and may be swept from vegetation in the vicinity of streams. Their food-habits are the same as those of Eriopterinae.

## KEYS TO GENERA

## LARVAE

1. Very large species, 35–45 mm. in length; paired pseudopods confined to segments 8–11; anal ventral blood-gills very long, about equal in length to the apical processes..... *Pedicia*.
- Smaller species, not exceeding 25 mm. in length..... 2
2. Ventral surface of apical abdominal segment with 4 slender protrusive blood-gills; spiracles conspicuous, situated on rather large elevations..... *Dicranota*.
- Ventral surface of apical abdominal segment without, or with very small, slender protrusive blood-gills; spiracles very small, situated upon small elevations..... *Rhaphidolabis*.

## PUPAE

1. Ventral abdominal segments without wart-like elevations; large species, more than 30 mm. in length..... *Pedicia*.

— Ventral abdominal segments each with a pair of wart-like elevations; small species, not more than 20 mm. in length. *Dicranota*.

### PEDICIA Latreille

I have not seen the immature stages of this genus, my information regarding them having been obtained from published descriptions. These justify the following generalizations for the larvae and pupae.

#### GENERIC CHARACTERS

*Larva*.—Head narrow, similar in general structure to that of *Dicranota* (Pl. XXXIV, Fig. 9), the dorsal surface compact, arcuate; mandibles slender, the apical tooth long and pointed, inner lower margin with several smaller teeth; maxillary palpi longer and stouter than the antennae. Body with weak isolated hairs, or bare, the segments distinct; ventral surface of segments 8-11 each with a pair of transverse pseudopods, the apices of which are not armed with spinules; apical segment with 2 long terminal processes, at the base of which, on the dorsal surface of the apical segment, are the spiracles on slight elevations; ventral anal blood-gills, when fully extended, as long as terminal processes.

*Pupa*.—Differs from that of *Dicranota* in the absence of ventral protuberances.

#### HABITS OF LARVAE

The larvae are aquatic and usually occur in still water—in springs or wells. They feed upon algae, diatoms, and small crustaceans.

#### HABITS OF IMAGINES

The flies of this genus are very large, and the wing-markings and conspicuously marked abdomen of the common species render their detection in nature very easy. Their flight is slow and heavy, and they seldom rise much above the level of the rank vegetation in the marshy or wet situations in which they normally occur.

### PEDICIA ALBIVITTA Walker

*Pedicia albivitta* Walker, List of Diptera in British Museum Coll., Pt. I (1848), p. 37. Imago.

Tipulid sp.? Needham, Bull. 68 N. Y. State Mus., p. 285. (1903)

Needham, in the bulletin cited above, described and figured the larva and pupa of this species.

The species is represented in our collection by an imago from New York State.

DICRANOTA Zetterstedt

I have the larva of one species of this genus, which is described herein. I have used Miall's description of a European species as an index to the pupal characters of the genus, as this stage is unknown to me.

The characters for the separation of the larvae of this genus from those of *Pedicia* and *Rhaphidolabis* are summarized in the synoptic key.

DICRANOTA sp. ?

*Larva* (Pl. XXXIV, Fig. 7).—Length, 10 mm. Whitish yellow. Head black.

Head long and narrow, posterior portion in the form of a compact arcuate capsule, the sutures poorly defined except in middle and on posterior margin (Pl. XXXIV, Fig. 9). Antennae long and slender (Fig. 6); maxillary palpi about the same length as antennae but much stouter (Fig. 5), the sensory area very distinct; mandibles long and slender, the apical tooth very acute, inner lower margin with 2-3 smaller teeth; labium divided centrally, each side with 3 sharp teeth, the median one of each trio smaller than the others. Segments of body well differentiated, clothed with close decumbent pile and without distinguishable bristles; 5 pairs of pseudopods on ventral surfaces of apical 6 segments exclusive of the last one, their apices armed with spines; spiracles situated on a pair of short processes at base of the prolonged apical protuberances; ventral blood-gills short, 4 in number.

Described from a specimen taken by Dr. S. A. Forbes among weeds and stones in a stream on Bottlers Ranch, Yellowstone National Park, September 14, 1891.

DICRANOTA BIMACULATA Schummel

*Dicranota bimaculata* Schummel, Miall, Trans. Ent. Soc. London, 1893, pp. 235-253. Larva and pupa.

Prof. L. C. Miall published a detailed account of the life history and anatomy of this species in the paper cited above. In general the larva agrees with the one just described, the differences being found in the structure of the head. I have, however, to rely upon Miall's description and figures of the pupa for details of that stage.

*Pupa*.—Thoracic respiratory organs elevated, rather stout, their

apices with truncated knobs. The abdomen is furnished upon the middle of the dorsum of the second and sixth segments with a roughened plate clothed with short coarse spines, and the intervening segments each have 2 such plates, one before, and the other behind, the middle. Ventral segments 3-7 each with a pair of widely separated papilliform tubercles in a transverse line at middle. Apical segment elongate, without spines.

This species is aquatic in the larval stage, but pupates in moist earth along the banks of the streams in which the larvae occur. The larvae feed upon the worm *Tubifex rivulorum*.

#### RHAPHIDOLABIS Osten Sacken

I have but one larva that I regard as belonging to this genus. It very closely resembles that of *Dicranota*, differing in being slightly more slender; in having the pseudopods armed with a more regularly curved semicircle of apical spinules, the spiracles much smaller and less elevated, the apical processes longer; and in the apparent absence of the ventral blood-gills.

This specimen was taken by Dr. S. A. Forbes among vegetable refuse in Blacktail Deer Creek, Yellowstone National Park, August 28, 1890.

The larva of *R. tenuipes* has been figured by Needham\*.

The species are aquatic in the larval stage, occurring in streams.

#### Subfamily LIMNOPHILINAE

I have before me representatives of but one genus of this subfamily, and have found descriptions of but two others of the ten genera which it contains.

#### SUBFAMILY CHARACTERS

*Larva*.—Head well chitinized, much as in *Tipula*, the principal differences being the much longer maxillary palpi, which exceed the antennae in length, and the less robust mandibles. The labium also shows a departure from the tipulid type and is produced into a rather acute central point anteriorly, but the genera in which the structure of this plate is known to me differ materially, and a generalization is not justifiable, more particularly as both forms are found in other subfamilies. Apical abdominal segment with 4 or 5 protuberances on

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\*Twenty-third Rep. N. Y. State Ent., p. 201. (1908)

margin of stigmatal field; ventral blood-gills present or absent. Body with short silky pubescence or bare; bristles absent.

*Pupa*.—Head without chitinized protuberances; palpi straight. Thoracic respiratory organs long and slender, sometimes pointed apically. Legs extending much beyond apices of wings. Abdomen with weak armature, consisting of 1-3 transverse bands of weak spines and some longer slender hairs, or of only weak hairs, the segments with the usual transverse incisions, giving them a divided appearance.

#### HABITS OF LARVAE

The larvae of the genus *Ula* are fungivorous, living usually in Polypori; those of *Limnophila* and *Epiphragma* are aquatic or semi-aquatic, feeding upon algae and decaying vegetable matter, the last-named genus occurring in dead stems of plants.

#### HABITS OF IMAGINES

Most species of the subfamily fly in the evening, and they are not uncommonly attracted to lights.

#### KEYS TO GENERA

##### LARVAE

1. Apical segment with 2 long and 2 short processes which are fringed with very long hairs; labium divided centrally.....*Limnophila*.
- Apical segment with 4 or 5 short, pointed processes which are inconspicuously or not at all fringed.....2
2. Apical segment with 4 processes.....*Epiphragma*.
- Apical segment with 5 processes.....*Ula*.

##### PUPAE

1. Thoracic respiratory organs rather short, swollen at base and acute at apices.....*Epiphragma*.
- Thoracic respiratory organs long and slender, of nearly uniform thickness throughout their entire length, not acute at apices.....2
2. A number of hairs on frons between antennae.....*Limnophila*.
- No hairs on frons between antennae.....*Ula*.

#### LIMNOPHILA Macquart

##### GENERIC CHARACTERS

*Larva*.—Head moderately chitinized, the ventral, median posterior opening large. Antennae short and slender, with a long apical hair,

or 2 such hairs; frontal plates large; maxillary palpi longer and much stouter than antennae; labial plate divided in center, the lateral pieces digitate. Apical segment with 4 long processes which are furnished with long fringes; pseudopods absent.

This description applies to aquatic forms only; the terrestrial forms are unknown to me.

*Pupa*.—Palpi straight; antennae extending to or beyond bases of wings. Thoracic respiratory organs long and slender, least chitinized at apices; legs extending beyond apices of wings, disposed side by side. Abdomen with a number of transverse setigerous ridges on each dorsal and ventral segment, or with distinct tubercles in similar series.

#### HABITS OF LARVAE

The only larvae known to me are aquatic. The very long fine hairs on the apical abdominal segment take a very firm hold of the surface of the water when the processes which they border are expanded, and it requires considerable effort on the part of the larva to detach them in order to descend. Hart has stated that detachment is accomplished by throwing the cephalic extremity round in such a way that the thoracic segments pass over the apex of the abdomen, and thus their hold on the surface of the water is released. I have frequently seen the larvae do this, but only in water too deep for them to get hold of anything in the bottom. A considerable quantity of air is carried down within the confines of the fringes of the apical processes when the larva descends below the surface of the water, and when this is exhausted the larva ascends for a fresh supply. In cases where the specimens are able to feed without entirely submerging the body, the apical segment is expanded on the surface of the water and forms a conspicuous crater-like cavity within which are visible the eye-like anal spiracles.

The food consists of decaying vegetable matter and algae.

I have found the larvae common at Muncie and White Heath, Ill., but only along the margins or in the muddy banks of streams.

I have reared two species, but the larva of only one of them has been associated with the pupa and imago.

#### LIMNOPHILA LUTEIPENNIS Osten Sacken

*Limnophila luteipennis* Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 236.

The larva and pupa are described by Hart in the paper frequently cited herein\*, and the following details should be accepted as supplementary to that description.

\*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, pp. 202-204.

*Larva* (Pl. XXIX, Fig. 4).—Length, 15–18 mm. Yellowish testaceous or slightly olivaceous.

Head dorsally as in Figure 7, Plate XXXIII, the antennae short and slender (Pl. XXXIII, Fig. 2); mandibles as in Figure 15, Plate XXXIII, being quite different in form from those of Hexatominae and more resembling those of *Limnobia*; labium (Pl. XXXIII, Fig. 3) divided in center, each half with 7 teeth; maxillary palpi with 3 joints. Body with rather conspicuous surface hairs which are situated on slight transverse ridges; apical segment (Pl. XXX, Fig. 1) with 2 short upper and 2 long lower processes which are fringed with very long hairs; ventral blood-gills 4 in number.

*Pupa* (Pl. XXIX, Fig. 5).—Length, 10–13 mm. Color as in the larva.

Thoracic respiratory organs (Pl. XXXIII, Fig. 18) slightly longer than wings, their apices split; legs ending in a straight transverse line at apex of second abdominal segment; each dorsal abdominal segment except basal with 5 transverse series of hair-like bristles set on small chitinized elevations which form slight ridges, the posterior pair much more widely separated than the others. Ventral segments with 6 such transverse series arranged as on dorsal segments. Apical segment of female composed of 2 pairs of elongate processes which form an acute tip, the lower pair two thirds as long as the upper.

This species is probably present in every stream and river in the state, as I have found it wherever I have collected in March and April.

#### LIMNOPHILA TENUIPES Say

*Limnophila tenuipes* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 21. (1823)

I have obtained only the pupa of this species. It resembles *luteipennis* in general shape and in the arrangement of the cephalic and thoracic appendages, but in the armature of the abdomen there is a notable difference.

*Pupa*.—Length (exclusive of the respiratory organs), 10–15 mm. Blackish brown.

Thoracic respiratory organs rather more slender than in *luteipennis*. Abdominal segments, exclusive of the basal dorsal, those covered by the legs, and the apical one, each with 3 transverse pairs of widely separated protuberances, the distance between those of each series less than the distance from either to the lateral margins; distance between the most posteriorly placed pair and posterior margin of segment greater than the distance between the pairs; posterior margin with

4-6 smaller protuberances which, like the others, are armed at apices with 1-2 weak hairs; lateral margins with a tubercle at a point corresponding to the situation of the dorsal and ventral transverse series; apical segment of male and female as in Figures 8 and 9, Plate XXXIII.

I collected a large number of pupae of both sexes of this species on the banks of the Sangamon River at White Heath, Ill., May 28, 1916. I found that by taking mud from the bank and disintegrating it in the water I could readily obtain the pupae as they floated at the surface. The species is common in Illinois, and probably occurs in most of its streams. The pupa was described by Mr. Hart as *Limnophila* species (*a*) in his paper previously referred to.

#### EPIPHRAGMA Osten Sacken

I have not seen the early stages of this genus, but those of *fascipennis* have been described by Needham, as indicated in the synonymy under the species name.

#### GENERIC CHARACTERS

*Larva*.—Details of the cephalic structure are lacking in Needham's description, and as I have no means of ascertaining these, only the superficial characters can be indicated. Body cylindrical, without surface hairs or bristles; ventral pseudopods represented by fusiform ventral areas; apical abdominal segment with 4 short marginal processes and 4 slender protrusive ventral blood-gills.

*Pupa*.—Thoracic respiratory organs much shorter than in *Limnophila* and *Ula*, and more horn-like than tube-like, their apices incurved and acute. Legs extending beyond apices of wings the length of 2 abdominal segments, terminating in an almost straight transverse line. Abdomen without thorn-like armature, only bristly hairs present at apices of segments.

#### EPIPHRAGMA FASCIIPENNIS Say

*Limnobia fascipennis* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, p. 19. Imago. (1823)

*Epiphragma pavonia* Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 239. Imago.

*Epiphragma fascipennis* Say, Osten Sacken, Mon. N. Am. Dipt., Vol. 4, p. 194. Imago. (1869)

*Epiphragma fascipennis* Say, Needham, Bull. 68, N. Y. State Mus., p. 281. Larva and pupa. (1903)

*Larva* (Pl. XXXV, Fig. 2).—Length, 19 mm. White, or faintly tinged with yellowish.

Head large for the family. (No structural description given by Needham.) On the ventral side of the three thoracic segments is a pair of minute brownish points. Ventral side of segments 2-7 each with a single median proleg—a mere soft, white, transversely placed ridge, without hooks or claws. The abdomen is without other tubercles, spines, or hairs. Spiracles large, widely separated. Spiracular disc with 4 thick marginal processes, the upper pair blunt apically, fringed with hairs, and separated by the full width of disc, the lower pair a little more pointed and a little closer together (Pl. XXXV, Fig. 3). Anal blood-gills slender, 4 in number.

*Pupa* (Pl. XXXV, Fig. 9).—Length, 12 mm. Ventral view and general appearance as in figure. Apical carina on each abdominal segment fringed with short stiff hairs, those on the ventral side of eighth segment more comb-like, and interrupted on the median line in female.

The foregoing descriptions are abridged from Needham's paper, and the accompanying figures are copied from the same author.

The materials used by Needham in making his descriptions were obtained at Lake Forest, Ill., where the larvae were found boring in the dead stems of buttonbush and willow lying on the mud at the borders of shallow pools.

The species is represented in our Laboratory collection by imagines from Algonquin and Urbana, Ill., and from Philadelphia, Pa., all being taken in June.

#### ULA Haliday

##### GENERIC CHARACTERS

*Larva*.—Body cylindrical, without hairs; pseudopods faintly indicated in the form of slight transverse ventral fusiform areas on apical portion of abdomen. Labium entire; maxillary palpi longer than the rather stout antennae. Apical abdominal segment with 5 processes on margin of spiracular disc.

*Pupa*.—General appearance similar to that of *Limnophila*, but the armature of the abdomen differs noticeably in being confined to the posterior margins of the median dorsal segments.

#### ULA ELEGANS Osten Sacken

*Ula elegans* Osten Sacken, Mon. N. Am. Dipt., Vol. 4, p. 276. Imago. (1869)

*Ula elegans* Osten Sacken, Alexander, Pomona Jour. Ent. and Zool., Vol. 7, pp. 1-8. (1915)

*Larva*.—Length, 8.5–11.9 mm. White, the head brownish black, shining.

Antennae short and stout, armed at apices with 2 short processes; labium with a small central tooth, the first lateral on each side distinctly larger and extending anteriorly beyond the apex of the central one, sides of plate sloping abruptly backward, armed with 3 teeth; mandibles stout, their inner margin with 2 teeth in addition to the apical one. Apical abdominal segment with the dorso-central process small, the lateral much longer and slightly more pointed than the latero-ventrals, all fringed with marginal short hairs and each with conspicuous black mark on the posterior surface; anal blood-gills absent.

*Pupa*.—Head without anterior protuberances. Palpi curved slightly forward at their apices. Thoracic respiratory organs long and slender, dark basally, pale apically; legs extending to middle of fourth segment beyond apices of wings. Dorsal abdominal segments 2–6 each with a noticeable transverse subchitinized band of a shagreened texture; the disc of segments with small setigerous punctures.

The above descriptions are abridged from Alexander's, reference to which is given under species name. Alexander's material was obtained at Ithaca, N. Y. The larvae feed in fungi, *elegans* being taken in a species of *Fomes* (*Polyporus*) growing on a tree-stump. The imagines emerged in September and October.

The species occurs throughout the Atlantic states and is recorded from Wisconsin, so that it probably occurs in Illinois though we have no record of it.

#### Subfamily RHAMPHIDIINAE

The only information I have regarding the larval and pupal stages of this subfamily is that contained in the description of the European species *Elliptera omissa*. The larvae of *Rhamphidia longirostris* has been found by Gericke, but he did not describe it.

The characters of the larva and pupa of *Elliptera* as indicated by Mik are given below. One species of this genus, *clausa* Osten Sacken, occurs in North America.

#### ELLIPTERA OMISSA Egger

*Elliptera omissa* Egger, Verh. d. zool.-bot. Ges., Vol. 13, p. 1108. Imago. (1863)  
*Elliptera omissa* Egger, Mik, Wiener Ent. Zeit., 1886, p. 337. Larva and pupa.

*Larva*.—Length, 7 mm., breadth, 1.5 mm. More robust than most members of the family, the segments distinctly broader than long.

Head heavily chitinized, dorsum with the usual 2 longitudinal dorsal excisions and a smaller median posterior one. Antennae short and slender. Labium heavily chitinized, triangular in outline, margin dentate. Mandibles strong, curved, their inner margin dentate. Body slightly flattened dorso-ventrally, the segments distinct, with decumbent pale pile, and having long bristle-like hairs on lateral margins of each segment, 1 on the prothorax and 2 on each of the other segments. Abdominal segments 2-8 each with a narrow transverse fusiform stripe on ventral and dorsal surfaces near the anterior margins which is armed with short spinules. Apical segment tapered, cleft, the margins of the cleavage with 2 upper and 2 lower processes, each pair margined with fine hairs.

*Pupa*.—Length, 6.5 mm. Yellowish brown, the abdomen greenish white.

Thoracic respiratory organs about as long as diameter of thorax, very stout, their bases almost contiguous, tapering from base to apex, and more or less resembling the pincers of a crab. Abdomen armed as in larva except that the lateral hairs are wanting. Legs extending to base of antepenultimate abdominal segment. Apical segment prolonged slightly in both sexes, that of the female a trifle the longer, a few small processes present in both sexes at base.

This genus agrees well in the larval and pupal stages with the corresponding stages of *Dicranomyia*, the distinctions between them being less marked than is the case with allied genera of some other subfamilies.

#### Subfamily ERIOPTERINAE

*Helobia* and *Gnophomyia* are the only genera of this subfamily of which identified larvae and pupae are before me. I have, however, an unidentified larva that quite obviously belongs here. There is a great similarity in these larvae, but judging from the available descriptions of European species of other genera a great difference exists between the forms I have and those of other European genera. The description of the larva of *Trimicra* agrees with the characters generally attributed to larvae of Pediciinae—a fact that to my mind throws considerable doubt upon the correctness of the present subfamily-grouping, which is based upon characters of the imagines. I have no intention of rearranging the genera in this or any other subfamily upon the basis of characters deduced from printed descriptions, and accordingly leave the subfamilies practically as in Williston's "Manual", but consider it essential to indicate the probability of errors in the arrangement.

I do not include in the following synopsis of characters, nor in my keys, genera which I do not possess, though they may have been described by other authors; but notes upon *Erioptera* are given in the text owing to the existence of a previous record of the occurrence of a larva of that genus in Illinois.

#### SUBFAMILY CHARACTERS

*Larva*.—Slender, cylindrical, tapering slightly towards both extremities, the body covered with dense decumbent pile. Head small, poorly chitinized; labium unchitinized; the main portion of head consisting of slender chitinized rods, 4 or 6 in number.

*Pupa*.—Head as in *Limnobiinae*, without projections; palpi straight; directed laterad. Thoracic respiratory organs short, or if of considerable length, still noticeably shorter than those of *Limnophilinae* known to me, and of a uniform strength throughout; legs longer than wings. Abdomen with weak armature, which is not in the form of transverse bands or series of spinules; spiracles distinct.

*Imago*.—See key to subfamilies.

#### KEYS TO GENERA

##### LARVAE

1. Body with almost indistinguishable surface hairs; ventral surface of abdominal segments without distinct transverse pseudopod-like swellings. .... *Helobia punctipennis*.
- Body covered with rather long and very dense decumbent hairs which give the larva a silky appearance; ventral surface of abdominal segments with distinct transverse pseudopod-like swellings. .... *Gnophomyia tristissima*.

##### PUPAE

1. Thoracic respiratory organs pressed close against surface of thorax; legs extending very slightly beyond apices of wings (Pl. XXVIII, Fig. 15). .... *Gnophomyia tristissima*.
- Thoracic respiratory organs erect, tube-like, not pressed against surface of thorax; legs extending very far beyond apices of wings. .... *Helobia punctipennis*.

#### HELOBIA St. Fargeau

##### GENERIC CHARACTERS

*Larva*.—Cylindrical, slightly tapering towards the extremities. Head small, entirely retractile, caudad of mandibles consisting of 6

chitinized rods with weakly chitinized connecting membrane. Body with very indistinct surface pilosity. First thoracic segment with an indistinct transverse median division. Abdominal segments 2-7 with a median transverse constriction or division. Apical segment with 5 stout protuberances.

*Pupa*.—Differs from the pupa of *Gnophomyia* in the structure of the thoracic respiratory organs, which are slender and elongate. The legs also are more elongate than in *Gnophomyia*.

#### HABITS OF LARVAE

The larvae are found in mud and sand along the margins of streams. They burrow in the wet sand and are able to live under water like the larvae of *Limnophila*, though they are less commonly found there.

#### HABITS OF IMAGINES

The imagines are very common throughout Illinois and usually fly in the late afternoon. They are readily attracted to lights at night. They may feed upon nectar, but the mouth parts are poorly developed.

Our species occurs also in Europe.

### HELOBIA PUNCTIPENNIS Meigen

*Limnobia punctipennis* Meigen, Syst. Beschr. Eur. Zweifl. Ins., Vol. 1, p. 17. (1818)

*Larva* (Pl. XXIX, Fig. 6).—Length, 8-10 mm. Pale yellowish testaceous.

Head (Pl. XXXIV, Fig. 18) poorly chitinized, the posterior portion consisting of slender blackish rods, the intervening spaces filled with weakly chitinized membrane; antennae short, 2-jointed, the apical joint very short; maxillary palpi longer than antennae and much stouter; mandibles stout, their lower margin toothed (Pl. XXXIV, Fig. 11); labium apparently not chitinized, indistinguishable in my specimens. Body covered with short decumbent pile, which is less conspicuous than in the other larvae of this subfamily. Segments with the usual transverse linear incision on dorsum; apical segment as in Figure 17, Plate XXXIV.

*Pupa* (Pl. XXIX, Fig. 7).—Length, 7-9 mm. Color as in the larva.

Thoracic respiratory organs tube-like, from 6 to 8 times as long as their greatest diameter; prothorax flattened, declivitous, with an elongate, rather broad foveate mark on each side of dorsum; anterior margin of mesothorax with a slight ridge-like swelling, upon which are

numerous small spinules and, laterally, 2 or more small tubercles; legs extending well beyond apices of wings, apices of fore tarsi extending beyond apices of mid pair, apices of hind pair extending beyond apices of fore pair. Abdomen without noticeable armature; apical segment of female elongate, the upper processes longer than the lower, that of male obtuse, with 7 slight protuberances, 3 in a transverse line before apex on dorsum and 4 at apex—2 above and 2 below, the latter acute.

The material used in drawing up the foregoing descriptions is that which Mr. Hart had when he wrote his paper on Illinois River species. He did not describe the early stages, referring merely to Beling's description of them which appeared in a European publication.

### GNOPHOMYIA Osten Sacken

#### GENERIC CHARACTERS

*Larva*.—Head rather small, wholly retractile, posteriorly composed of slender chitinized rods. Body covered with dense silky hairs. General form similar to that of *Helobia*, the principal differences being the much less conspicuous hairs on the surface of the latter, the absence of distinct ventral locomotor organs, and the longer radiating processes of the apical segment.

*Pupa*.—The structure of the thoracic respiratory organs sufficiently distinguishes this genus from *Helobia*.

#### HABITS OF LARVAE

The larvae live in mud, especially along the banks of streams.

#### HABITS OF IMAGINES

The flies are usually found in damp situations, especially in grass along the margins of ponds or streams. They feed on nectar or liquids.

### GNOPHOMYIA TRISTISSIMA Osten Sacken

*Gnophomyia tristissima* Osten Sacken, Proc. Acad. Nat. Sci. Phila., 1859, p. 224.

*Larva*.—Length, 9-11 mm. Slender, slightly tapering towards both extremities, more decidedly towards the cephalic. Body yellowish testaceous, covered with dense decumbent pile.

Head more compact than that of *Helobia*, the lateral rods stouter (Pl. XXXIV, Fig. 10); antennae very small; maxillae large, pro-

duced beyond the apex of the narrow labrum, the palpi stout; labium not chitinized; mandibles slender, with a long sharp apical tooth and about 3 poorly defined teeth along the lower lateral margin. Locomotor organs consisting of rather broad fusiform areas on anterior portion of abdominal segments except basal and apical; hairs along margins of segmental incisions more distinct than elsewhere because of their being slightly curved upward; apical segment with 5 processes, their structure and markings as in Figure 16, Plate XXXIV; anal ventral blood-gills in the form of 4 short rounded protuberances.

*Pupa* (Pl. XXVIII, Fig. 15).—Length, 8-10 mm. Color as in larva.

Thoracic respiratory organs very little elevated, in the form of longitudinal ridges very similar to those of some Tabanidae. Prothorax not so decidedly declivitous as in *Helobia*. A very long hair on each side of thorax just above and slightly in front of base of wing; front view of thorax and appendages as in Figure 15, Plate XXVIII. Lateral margins of abdomen with long hairs situated upon slight elevations, as shown in figure last mentioned; spiracles larger than in most genera in the family, 6 pairs distinct; apical segments of male and female as in Figures 16, 17, and 18, Plate XXVIII.

The foregoing descriptions are made from specimens supplied by J. A. Hyslop and taken at Wolfville, Md., May 20, 1913.

The larvae are found in wet mud along the banks of streams or other bodies of water. The species is common in Illinois.

#### ERIOPTERA Meigen

The larvae of two European species of this genus have been described by Beling. He does not appear to have paid much attention to the structure of the head of any larva that he described, the only characters mentioned being those of general shape, armature, or clothing of the body, the absence or presence of pseudopods, and the shape of the apical segment. The species, judging from his description, differ from those of allied genera in having the thoracic segments distinctly swollen and the body noticeably tapered posteriorly. The apical segment is armed with 5 short processes as in *Gnophomyia* and *Helobia*.

The species described by Hart as *Erioptera* species (a) in his paper on the Entomology of the Illinois River, is not an *Erioptera* according to this generalization, but is, I think, much more closely related to *Gnophomyia* than to *Elliptera*, contrary to Mik's opinion\*. I figure

\*Wiener Ent. Zeit., Vol. 16, 1898, p. 62.

the head of this species and briefly describe it on a subsequent page of this paper under the heading Genus incertus 2.

### Subfamily HEXATOMINAE

#### SUBFAMILY CHARACTERS

*Larva* (Pl. XXXIV, Fig. 14).—Very slender; aquatic or semi-aquatic. Head flattened, not so heavily chitinized as in other sub-families (Pl. XXXIV, Fig. 12). Maxillae with a long, slender, pointed process at outer anterior angle, the processes having been erroneously designated as maxillary palpi by some authors. Antennae short and slender. Labial plate not chitinized, indistinguishable. Mandibles long and slender, sickle-shaped, the teeth confined to base or basal half of inner surface. Body without distinct pseudopods, usually covered with silky hairs; apical segment terminating in 4 slender processes which are fringed with long fine hairs (Pl. XXXIV, Fig. 13).

*Pupa*.—Head produced in the form of 2 wart-like protuberances at bases of antennae, bases of the latter, especially in male, swollen, their apices extending to or beyond apices of wings. Thoracic respiratory organs long and slender, sometimes acute apically; legs extending well beyond apices of wings. Abdomen with a few weak hairs, the segments, except the basal one, usually with a preapical dorsal transverse band of small spinules.

#### HABITS OF LARVAE

The larvae of this subfamily are aquatic, but usually, as is the case with other aquatic Limnobiidae, they pupate in the mud alongside the stream in which the larvae occurred. The food consists of algae and vegetable debris.

#### HABITS OF IMAGINES

The imagines of this subfamily which we have observed, are most active in the late afternoon, flying in swarms over streams or along their margins. Usually they are sluggish, and may be swept from rank herbage along stream margins. I do not know their food-habits.

#### KEYS TO GENERA

##### LARVAE

1. Lower process on each side of apical abdominal segment with a very long terminal hair in addition to the fringe of short hairs along margin. .... *Penthoptera*.

- Lower process on each side of apical abdominal segment with only the fringe of short hairs, no long terminal hair being present...2
- 2. Labrum with a leaf-like lobe on each antero-lateral angle which is directed anteriorly and mesad, the pair almost meeting so as to shield the anterior margin of the labrum.....*Hexatoma*.
- Labrum either rounded or but slightly produced at the antero-lateral angles, lobes, if present, not directed mesad, and the apices of the pair widely separated.....*Eriocera*.

#### PUPAE

- 1. Apices of fore tarsi ending much proximad of apices of mid and hind pairs.....*Hexatoma*.
- Apices of fore tarsi ending on a transverse line with mid pair, the hind pair sometimes extending distad of the latter.....2
- 2. Thoracic respiratory organs very noticeably swollen at bases and apices, the constricted central portion with transverse wrinkles.....*Pentoptera*.
- Thoracic respiratory organs of nearly uniform thickness throughout their length, sometimes tapering from near base to apex.....*Eriocera*.

I have before me a number of larvae of this subfamily, but can associate none of them with a described species as neither pupa nor imago are in the collection. Our specimens, with but one exception, were obtained by Dr. S. A. Forbes in rivers in Yellowstone National Park; the single one was taken by Dr. C. C. Adams in Montana. The species in their larval stage appear to be confined to swift-flowing streams. No examples have been obtained in Illinois though much careful work has been done on the Illinois River. It is not improbable that an examination of some of the smaller swift-flowing streams in the more hilly sections of the state will discover the presence of these larvae. They are usually found under stones when in the current, but come ashore to pupate in the sand or mud of the banks.

The species almost invariably have the appearance of Figure 14, Plate XXXIV, when preserved, the integument of the penultimate segment distending remarkably in some specimens. Brauer, in his paper previously referred to, has figured a species with this characteristic distension. The long membranous appendages of the maxillae probably serve the purpose of guiding the food into the mouth, being analogous to the mouth-fans of the family Simuliidae—also found in swift-flowing waters.

## Subfamily TRICHOCERINAE

I have before me a single specimen of the larva of a species of *Trichocera*. The pupa is unknown to me.

In many respects the larva resembles that of *Rhyphus*, but the affinities of the imago are clearly with the Limnobiidae, and for this reason I retain it here, though with some hesitation.

## TRICHOCERA Meigen

## GENERIC CHARACTERS

*Larva*.—Head different from that of all other Limnobiidae in having a complete capsule, closely resembling in this respect Ptychopteridae and Rhypidae, the ventral surface especially resembling that of the latter; mandibles stout, with distinct teeth. Body covered with decumbent pile. Prothorax with distinct spiracles. The apical segment is noticeably more slender than the preceding one and armed with 4 finger-like processes surrounding the spiracles.

*Pupa*.—Head and thorax with hairs much as in Rhypidae, the cephalic hairs very similar to those of *Limnophila*. The thoracic respiratory organs are horn-like. The abdomen is armed as in *Limnophila* and has incisions similar to those present in that genus.

*Imago*.—See key to subfamilies.

## HABITS OF LARVAE

The larvae are found in decaying vegetation and under leaves.

## HABITS OF IMAGINES

The genus *Trichocera* contains the so-called "winter-gnats" of Europe. They fly in mild weather throughout almost the entire winter in Britain, and are frequently seen flying over snow and settling upon it where the sun falls on it.

It is remarkable that this very common genus is unrepresented in the materials in our Illinois collection.

## TRICHOCERA sp.?

*Larva* (Pl. XXXVI, Fig. 1).—Length, 7.5 mm. Pale testaceous, the head with brown marks on each side of central sclerite of dorsum in front of antennae, and along posterior margin.

Antenna small, consisting of a slender apical process situated on

an elevated base; mandibles similar to those of Rhyphidae in that they consist of a stout basal piece and an articulated apical one, the latter with several teeth; labium small, rounded anteriorly, the appendage above it (mentum) similarly shaped, both armed with numerous hairs (Pl. XXXVI, Fig. 10); labrum overhanging oral orifice, the epipharynx armed with numerous strong spinules; maxillae and their palpi similar to those of *Rhyphus punctatus*; eyes pigmented, situated on side of head instead of being on dorsum as in *Rhyphus*. Body with short decumbent pile; segments of thorax bisected, those of abdomen trisectioned; pseudopods absent; apical segment with 4 finger-like processes, the lower pair longer than the upper and furnished with some delicate hairs at apices.

The specimen described above was taken by A. G. Whitney on St. Paul Island, Bering Sea, March 23, 1913, and formed part of a collection submitted to me for identification by the U. S. Bureau of Biological Survey.

#### LIMNOBIID LARVAE OF UNCERTAIN GENERIC LOCATION

I have based the synoptic key to the larvae of the subfamilies upon species that I have reliable identifications for, but certain larvae that I have before me are not in agreement with the characters cited, or they so vaguely resemble those that are identified as belonging to the various subfamilies that I have deemed it wisest to describe them independently, in the hope that further light may be shed upon their position in the classification by some student of the group who may succeed in rearing them.

I realize that there are in store for us many surprises in the larval and pupal characters of species that are as yet unknown in these stages, and hope that the present effort to assign characters for the separation of the subfamilies may be improved upon rapidly after it appears in print.

#### GENUS INCERTUS I

*Larva* (Pl. XXXV, Fig. 11).—Length, 10 mm. Golden yellow, covered with silky hair which gives the larva a satiny appearance. Tapering on thoracic segments towards head. Head almost completely retractile, ventral aspect as in Figure 16, Plate XXXV; oesophagus conspicuous, its sides with very prominent ridges which meet angularly in center; maxillary palpi 2-jointed, of moderate size; mandibles barely distinguishable in mount (see figure last mentioned); posterior portion of head consisting of 4 rods, the dorsal pair more elongated

than the ventral and thickened apically. Thorax and abdomen densely covered with closely appressed silky pile; dorsum of thoracic and abdominal segments each with a transverse series of short, closely placed, backwardly directed spines at suture, the abdominal segments with 3 additional transverse series which do not traverse the whole dorsum and are usually interrupted in one or two of the series; ventral segments each with 2 transverse series of similar locomotor spines on all but the apical 4, these latter bearing a series at the sutures and a transverse mouth-like incision with slightly protruded membranous integument which is densely clothed with short upright hairs (Pl. XXXV, Fig. 14); hairs in front of the transverse incision on apical segment very long; locomotor spines barely distinguishable except when the larva is alive and in motion; apical segment terminating in 4 rather long stout processes, on the inner under surface of the upper pair of which are the black, round, posterior spiracles, and on the lower pair a long apical hair (Pl. XXXV, Fig. 13).

The larva just described is one that I took from a much-decayed log at White Heath April 30, 1916.

It conforms to the general characteristics of the larvae of this family, but I have no means of determining its specific identity as the only specimen I obtained died before pupation.

The head and thoracic segments were dissected and mounted in Canada balsam; the remainder preserved in alcohol.

The structure of the head points to the likelihood of the species belonging to Eriopterinae.

#### GENUS INCERTUS 2

*Larva* (Pl. XXXIV, Fig. 8).—Length, 5-7 mm. Yellowish white, with the head and locomotor areas showing blackish.

Head as in Figures 1, and 4, Plate XXXV, the general shape resembling that of *Limnobia*; mandibles stout, with apical and lower marginal teeth; labial plate of the same form as in *Limnobia*. Body slender, the segmentation distinct; locomotor organs consisting of transverse, elevated, slightly leathery areas which are not armed with spinules, their number and arrangement as in Figure 8, Plate XXXIV. Apical segment terminating in 2 long tapering processes which are armed with a number of long hairs, as in Figure 15, Plate XXXIV. Spiracles situated on dorsum at base of terminal processes, their openings not conspicuous nor chitinized.

Described from 4 specimens obtained by Dr. S. A. Forbes from Firehole River below Nez Perce Rock Rapids, Yellowstone National Park, August 16, 1890.

The description of the larva of *Trimicra pilipes* Meigen is not unlike that of the present species, but in the former the locomotor organs consist of paired pseudopods, and it is probably a true pediciine species, whereas the one above described may prove to be an aberrant limnobiine, resembling Pediciinae only in the structure of the apical segment.

#### GENUS INCERTUS 3

This is the larva described and figured by Mr. Hart as *Erioptera* species (a). Judging from the characters of the larvae of *Erioptera* summarized on a previous page this species does not belong to that genus. The head is quite different from that of *Helobia*, the dorsum being much more compact, as is shown in Figure 19, Plate XXXIV. I believe that the species really belongs to Eriopterinae, as the superficial characters ally it more closely with that subfamily than with any other. The larva and its apical segment are shown in Figure 8, Plate XXIX, and in Figure 5, Plate XXX, respectively.

For a full description of the species see Mr. Hart's description\*. The larva lives among floating weeds in the Illinois River.

#### GENUS INCERTUS 4

*Larva*.—Length, 15 mm. Slender, the segments distinctly longer than broad, the body of almost uniform thickness.

Head very similar to that of *Helobia*, the median posterior rod even more slender than in that genus; dorsal plate (fronto-clypeus) longer and more slender and pointed than in *Helobia*; maxillary palpi tapering, extending very much beyond the apex of labrum, with distinct constrictions on apical third, giving them the appearance of having 3 joints. Body covered with dense yellow decumbent pile, most conspicuous at posterior margins of thoracic segments because there it is slightly turned upward. Abdomen without distinct locomotor organs; penultimate segment swollen much as in Hexatominae; apical segment with 4 short backwardly directed protuberances, the upper pair distinctly shorter than the lower; anal blood-gills inconspicuous.

The foregoing description was made from a specimen in the Laboratory collection bearing the accession number 26785, the accompanying data being as follows: Blacktail Deer Creek, Yellowstone National Park, August 28, 1890; taken under stones in the water (S. A. Forbes).

\*Bull. Ill. State Lab. Nat. His., Vol. 4, Art. VI, pp. 198-199.

This species closely resembles Genus *incertus* 1 of this paper in head-structure and appearance, differing however in the absence of pseudopods. It undoubtedly belongs to the Eriopterinae.

PAPERS ON THE BIOLOGY OF NORTH AMERICAN LIMNOBIIDAE\*

*Cylindrotominae*

Alexander, C. P.

'14. Biology of the North American crane flies (Tipulidae, Diptera). II. Pomona Coll. Jour. Ent. and Zool., 6:105. (Contains full bibliography of the immature stages of the group.)

Osten Sacken, C. R.

'69. Monographs of North American Diptera. Part IV, p. 296. (Contains synopses of genera and species of imagines.)

*Limnophilinae*

Alexander, C. P.

'15. The biology of the North American crane flies (Tipulidae, Diptera). III. The genus *Ula* Haliday. Pomona Coll. Jour. Ent. and Zool., 7:1.

*Hexatominae*

Alexander, C. P.

'14. The biology of the North American crane flies (Tipulidae, Diptera). I. The genus *Eriocera* Macquart. Pomona Jour. Ent. and Zool., 6:12.

'15. The biology of the North American crane flies. IV. Tribe Hexatomini. Pomona Jour. Ent. and Zool., 7:141.

Family *PTYCHOPTERIDAE*

FAMILY CHARACTERS

*Larva*.—Head complete; mandibles opposed. Body long and slender, with well-developed pseudopods armed with spines or bristles; many of the hairs on head and body plumose; larva metapneustic, the tracheae extensile, in the form of a long slender membranous tube.

*Pupa*.—Thoracic respiratory organs very unequal in length, one many times as long as the other; fore tarsi overlying mid pair.

*Imago*.—Separable from Tipulidae and Limnobiidae by the absence of the seventh longitudinal wing-vein, and the rather poorly defined mesonotal suture.

\*See also papers listed in the bibliography of Tipulidae.

## HABITS OF LARVAE

The larvae are found in damp situations, frequently in water, and feed upon decaying vegetation and algae.

## HABITS OF IMAGINES

The imagines are usually found near streams or other bodies of water. They are frequently taken upon flowers. Several species of *Ptychoptera* are common in Europe, but they are much less so in North America, occurring but rarely in Illinois.

## KEY TO GENERA

## LARVAE

1. Body with transverse series of wart-like elevations surmounted by hairs; ventral cephalic sclerite conspicuously narrowed posteriorly ..... *Bittacomorpha*.
- Body without transverse series of wart-like elevations, but armed with hairs in transverse series; ventral cephalic sclerite slightly narrowed posteriorly ..... *Ptychoptera*.

## BITTACOMORPHA Westwood

This genus is represented by many examples of *clavipes*, in all stages, in the collection before me. This material was used by Mr. Hart in drawing up his description of the larval and pupal stages in the paper frequently mentioned herein. The superficial characters of the larva and pupa are well illustrated by Figures 4 and 6, Plate XXX. The following description should be regarded as supplementary to the previously published one.

## BITTACOMORPHA CLAVIPES Fabricius

*Tipula clavipes* Fabricius, *Mantissa Insectorum*, Vol. 2, p. 323. (1787)

*Larva* (Pl. XXX, Fig. 4).—Length, including extended respiratory tube, 50–60 mm. Pale brownish, with the dorsal surface of head marked with dark brown granulose elevations, and the transverse series of warts on body darker than remainder of ground-color (Pl. XXXV, Fig. 5).

Ventral surface of head as in Figure 8, Plate XXXV, the central sclerite very much narrowed posteriorly, the anterior margin concave; maxillary palpi and antennae longer than in *Ptychoptera*; labrum seen from above about half as long as broad; mandibles as in

Figure 15, Plate XXXV, a strong tooth on outer surface much before apex. Three pairs of distinct ventral pseudopods present, one on the posterior margin of each of the basal 3 abdominal segments, each pseudopod armed with a strong curved apical claw that may be retracted at will (Pl. XXX, Fig. 2); two protrusive blood-gills at base of respiratory tube.

*Pupa* (Pl. XXX, Fig. 6).—Length, inclusive of respiratory organ, 50–60 mm. Color like that of larva.

One thoracic respiratory organ very long, usually longer than body, the other aborted. Palpi very long, curved forward; antennae shorter than in Tipulidae and but little curved; fore tarsi concealing a portion of mid pair; arrangement of parts as in Figure 6, Plate XXXV.

This species is aquatic, living among floating vegetable debris. The imagines have been taken in various parts of the state, but the only Laboratory record for the larvae is Havana, on the Illinois River.

#### PTYCHOPTERA Meigen

I have found in the collection here a number of larvae of *Ptychoptera* taken more than twenty-five years ago by Dr. S. A. Forbes. As the species was not reared and the pupal stage is not in the collection, I am unable to compare the pupae of the genera or to give a specific identification for the form before me.

#### PTYCHOPTERA sp.?

*Larva* (Pl. XXXV, Fig. 12).—Length, 18–20 mm. with anal respiratory tube retracted. Differs noticeably from the larva of *Bittacomorpha* in the structure of the head and body, none of the corresponding parts of the two genera bearing more than a general resemblance to each other. The ventral sclerite of the head is very much broader than in *Bittacomorpha* and does not narrow so decidedly posteriorly; the mandibles differ from those of *B. clavipes* in having a number of stout spines on their outer surface before apex instead of a very strong tooth; the labrum is about 4 times as broad as long; and the surface of the head is smooth and almost unicolorous. A comparison of Figures 7 and 10, Plate XXXV, with those of *Bittacomorpha* (Pl. XXXV, Figs. 5, 8) will illustrate the main distinctions between the genera. The body differs from that of *Bittacomorpha* in lacking the transverse series of wart-like elevations that are so conspicuous in that genus.

The two lots of larvae from which the foregoing description was made, were collected by Dr. Forbes in Yellowstone National Park in 1890, one on August 8, in Yellowstone Lake, and the other on August 13 in Alum Creek, both collections being obtained among weeds.

### Family *RHYPHIDAE*

This family is very small, containing only three genera from North America. One of these, *Mycetobia*, has been but lately assigned to the family, having previously been regarded as belonging to the Mycetophilidae. According to the differentiating characters previously considered by taxonomists as of family value, *Mycetobia* appears to belong to Mycetophilidae rather than to Rhyphidae; but the larval and pupal characters unmistakably ally it very closely with *Rhyphus*. The early stages of *Olbiogaster* are not known to me. I have before me all stages of *Rhyphus punctatus* Meigen and *Mycetobia divergens* Walker, and describe and figure them herewith.

#### FAMILY CHARACTERS

*Larva*.—Very slender, tapering towards extremities. Head complete, subconical; antennae distinct; mandibles opposed; maxillary palpi poorly developed. Thoracic segments simple, longer than broad, and, like those of abdomen, circular in transverse section; prothoracic spiracles distinct. Abdominal segments divided transversely as in Therevidae; pseudopods absent; apical segment tapered; spiracles of moderate size, terminal, surrounded by 5 short processes in *Rhyphus*.

*Pupa*.—Slender. Head, between antennae, with 2 slight protuberances, each of which is surmounted by a weak hair; antennae curved round in front of and over upper margin of eyes, extending to bases of wings; palpi straight on apical portion and directed laterad. Thoracic respiratory organs but little elevated; fore tarsi overlying mid pair, the latter overlying hind pair, both mid and hind pairs surpassing apices of wings. Abdomen armed with 2 transverse series of thorns on each segment; spiracles small but distinct.

*Imago*.—The imagines of the three genera are more diverse in structure than are the genera in most families of the Nematocera, and it is possible that some future writer may separate them. A generalization of the generic characters will be found in the synoptic key to the Nematocera on a previous page.

## HABITS OF LARVAE

The larvae of *Rhyphus* are found in manure, decaying vegetation, and occasionally in cesspools or bodies of stagnant or impure water; those of *Mycetobia* are found in wounds on trees, feeding upon the exuding sap and its attendant fungus. Rarely both genera are found together.

I have found nematode parasites in the larvae of *Mycetobia* at Urbana, Ill.

## HABITS OF IMAGINES

Both *Rhyphus* and *Mycetobia* are found commonly on tree-trunks and on windows in houses. They feed upon nectar and liquid matter.

## KEYS TO GENERA

## LARVÆ

1. All segments conspicuously marked with dark brown; head but little shorter than prothorax; apical segment with 5 short but distinct processes round the spiracular disc. .... *Rhyphus*.
- Only the thoracic segments conspicuously marked, the markings yellowish or very pale brown; head conspicuously shorter than prothorax; apical segment with microscopic processes round the spiracular disc which are invisible except under a very high-power lens. .... *Mycetobia*.

## PUPAE

1. Spiracular opening of the prothorax rather large, circular, distinctly but not greatly elevated; thorns in transverse series near posterior margin of each abdominal segment rather widely separated. .... *Rhyphus*.
- Spiracular opening of moderate size, situated upon a conspicuous tubercle, with a ridge-like elevation extending caudad of it; thorns in transverse series near posterior margin of each abdominal segment close together, generally contiguous. .... *Mycetobia*.

## IMAGINES

1. Discal cell of wing absent. .... *Mycetobia*.
- Discal cell of wing present. .... 2
2. All branches of radius ending in margin of wing. .... *Rhyphus*.
- Second branch of radius ending in first. .... *Olbiogaster*.

## RHYPHUS Latreille

I have but one species of this genus represented by all three stages, consequently it is unnecessary to summarize the generic characters.

Only four species are recorded from the United States, two of which, *alternata* Say and *punctatus* Fabricius, occur commonly in Illinois.

### RHYPHUS PUNCTATUS Fabricius

*Rhagio punctatus* Fabricius, Mantissa Insectorum, Vol. 2, p. 333. (1787)

*Larva*.—Length, 9–10 mm., diameter, .75 mm. Yellowish white, with the greater portion of each segment marked with fuscous brown, the dark portion containing a number of rounded or elongate pale spots.

Head larger and more tapered anteriorly than in *Mycetobia*, the dorsal aspect as in Figure 4, Plate XXXVI; eye-spots distinct; antennae smaller than in *Mycetobia*; mandibles as in Figure 5, their apices blunt, without well-developed teeth, and obscured apically by long and dense hairs; maxillary palpi small; maxillae hairy; labium as in Figure 12, centrally with a deep incision. Thoracic segments sub-equal in length; prothoracic spiracles of moderate size, situated on side, about one third from posterior margin of segment. All abdominal segments with a distinct constriction about one fifth from the anterior margin; apical segment with a large smooth plate on ventral surface, the tip of segment with 5 short processes round margin of spiracular disc (Fig. 2).

*Pupa*.—Length, 6–8 mm. Of the same color as the larva.

Head with the same armature and general structure as *Mycetobia*. Thoracic respiratory organs much less elevated than in that genus, their apices not reaching nearly as far as anterior margin of antennae when seen in profile. Legs and wings as in *Mycetobia*, the principal difference, apart from the thoracic respiratory organs, lying in the armature of the abdominal segments, as indicated in key to genera and in Figures 8 and 9, Plate XXXVI.

I have before me larvae and pupae that I obtained June 24, 1916, from horse-dung at White Heath, Ill., and similar material submitted by J. A. Hyslop, obtained at Hagerstown, Md., from cow-dung.

The species is found in Europe and North America, and is usually very common throughout the warmer portion of the year. The larvae feed in decaying vegetable matter, manure, and occasionally in sewage or foul water. The imagines occur very often upon windows of houses and outbuildings, but are quite frequently found at rest upon tree-trunks. They feed upon exuding sap of trees and upon nectar of flowers.

## MYCETOPIA Meigen

I have before me all stages of the only described North American species of this genus. The early stages have been previously described by Johannsen and myself, and the figures given herewith are merely supplementary to these descriptions, references to which are given in the synonymy of the species.

## MYCETOPIA DIVERGENS Walker

*Mycetobia divergens* Walker, Ins. Saund., Dipt., Pt. 1, p. 418. Imago. (1856)  
*Mycetophila persicae* Riley, Prairie Farmer, June 15, 1867, Vol. 35 (n. s., 5),  
 No. 19, p. 397. Imago.  
*Mycetobia sordida* Packard, Guide to the Study of Insects, p. 388. Imago. (1869)  
*Mycetobia marginalis* Adams, Kans. Univ. Sci. Bull., Vol. 2, No. 2, p. 21. Imago. (1903)  
*Mycetobia divergens* Walker, Johannsen, Bull. 172, Maine Agr. Exper. Station, p. 223. Larva, pupa, and imago. (1910)  
*Mycetobia divergens* Walker, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 321. Larva and pupa. (1915)

*Larva* (Pl. XXXVI, Fig. 3).—Length, 11-13 mm., diameter, .60 mm. White, semitransparent, thoracic segments marked with yellowish brown.

The principal distinguishing features of this species as compared with *Rhyphus*, apart from the difference in color and shape of the apical segment, mentioned in key, are the more slender build of the body and the dissimilar structure of the head. The greatest difference is apparent in the form of the labial plate and mandibles, as shown in Figure 11, the mandibles in the present species being pointed, and armed on the upper margin with several teeth, while the labium is not centrally incised.

*Pupa*.—The principal differences between the two genera are emphasized in the key to pupae, and a comparison of Figures 8 and 9, Plate XXXVI, will show the general build of the cephalic, thoracic, and basal abdominal regions, as well as the armature of the latter, in which there are decided differences. The ventral aspect of the head, thorax, and base of abdomen is shown in Figure 6; the dorsal aspect of head and thorax in Figure 7.

The larvae of this species are very commonly met with in wounds on trees from which sap is exuding. They feed upon the sap or the fungus occurring in such situations, and the pupae are found among the loose bark, especially where it is damp. The imagines behave in

much the same manner as do those of Mycetophilidae, hiding away in chinks in the bark of trees, and frequently feigning death when disturbed. They are much more active than *Rhyphus* and generally shun the light, whereas the latter do not appear to do so. The food consists of exuding sap of trees.

### Tribe EUCEPHALA

I have retained in this tribe, which is one of those proposed by Brauer, three superfamilies, removing Bibionoidea to Oligoneura. The tribe contains an assemblage of families that show a considerable range of variation in the structure of practically all parts of the body in the larvae, but these all possess a complete head with opposed mandibles and usually a well-developed labium. The antennae are usually well developed, consisting in Chironomidae of four to six joints, but in Mycetophiloidea, exclusive of Bolitophilidae, these organs are rudimentary, being usually very slightly elevated clear spots, contrasting sharply with the dark color of the remainder of the head. Peripneustic forms are present in Bolitophilidae, Mycetophilidae, Sciaridae, and Chironomidae, while some of the other families contain species that have rudimentary abdominal spiracles. I have decided upon the present grouping of the genera after a consideration of the characters of all the stages. This arrangement is quite different from that outlined by de Meijere\* in a paper that appeared when my manuscript was almost completed. I am not dogmatic with regard to my arrangement of the families concerned, and it should prove interesting to students to compare the results as presented in the two papers.

As this paper is primarily intended as a handbook for the ready identification of immature forms of Diptera and not as a discussion of affinities, it is deemed inadmissible to bolster the classification suggested by lengthy argumentation. The proving or disproving of the suggested affinities is left to the future, and probably to other students.

In order to locate species of the tribe it is necessary to make use of the keys to the various stages of Nematocera on a previous page.

The structure and habits of the species are dealt with under the family, subfamily, or generic headings.

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\*Zool. Jahrb., Abt. f. System. Geog. u. Biol., Vol. 40, Pt. 3-4, 1916, p. 307.

## Superfamily *Mycetophiloidea*

This superfamily, as at present defined, includes the following families: Bolitophilidae, Mycetophilidae, Sciaridae, Macroceridae, and Platyyuridae.

The first three families contain, as I believe, the most primitive larval forms known to me, but the fifth has evolved a form that to my mind shows considerable specialization, while the imagines show less specialization, in so far as the wings are concerned, than do those of Mycetophilidae and Sciaridae. The early stages of Macroceridae are unknown to me.

### SUPERFAMILY CHARACTERS

*Larva*.—Head complete, the sclerites, ventrally, more or less distinctly separated, often connected by narrow chitinized strips; mandibles opposed, toothed; antennae poorly developed except in Bolitophilidae; maxillae differing from those of other Nematocera in having their inner margins serrate; maxillary palpi developed or undeveloped. Larvae peripneustic except in Platyyuridae, the latter without distinct lateral abdominal spiracles and with protrusive anal respiratory gills. Abdomen, and sometimes some or all of the thoracic segments, with locomotor spinules, or the entire body without such organs. Abdominal segments in Platyyuridae with conspicuous transverse ridges, giving the body an annular appearance.

*Pupa*.—Head small, sometimes retracted, bringing its anterior margin in line with anterior margin of thorax; antennae elongate, either curved over eyes or projecting in a straight line from upper margin of head to base of wing or slightly beyond that point. Thoracic respiratory organs sessile, very rarely elevated. Wings more or less closely adherent to body; legs long, straight, extending much beyond apices of wings. Abdomen with 6 pairs of spiracles and without distinct armature on dorsum; apical segment sometimes with 4 short spines.

*Imago*.—The imagines of this superfamily have the radial vein of wings with 2 or 3 branches. The species which have 2 branches only, lack the medio-cubital cross-vein. One of the subfamilies which I have placed in Mycetophilidae has the radius with 3 branches, but the second joins the first and forms a more or less elongated closed cell, and the medio-cubital cross-vein is absent. The antennae are filiform, very rarely thickened, and occasionally remarkably elongated and slender; the proboscis is usually short and fleshy, rarely elongate (*Asindulum* and *Eugnoriste*). For synoptic characters see key to imagines of Nematocera.

Family *BOLITOPHILIDAE*

## FAMILY CHARACTERS

*Larva*.—*Bolitophila* larvae differ from the larvae of Mycetophilidae in having 2-jointed, well-developed antennae, the head subquadrate, and the median dorsal sclerite truncated apically, its sides on posterior half being little or not at all convergent posteriorly. From the larvae of Platyyuridae it differs in having well-developed abdominal spiracles and the abdomen without conspicuous transverse elevated ridges.

The pupa is unknown to me.

*Imago*.—Differs from Mycetophilidae in having the radius with 3 branches and in the presence of the medio-cubital cross-vein, from Platyyuridae in its distinct medio-cubital vein, and from other families as indicated under the heading "Notes on Family". The species are generally more fragile than Platyyuridae and allied families.

## HABITS OF LARVAE

The larvae are mycetophagous, feeding upon fungi growing upon trees, under logs, or in dense woods or in fields.

## HABITS OF IMAGINES

The imagines are very rare in North America. They are usually found in woods, and particularly along the sides of ditches or streams in wooded localities, from the grass-grown overhanging banks of which they may often be beaten in spring and fall. They hibernate in these situations in Europe, and very probably in this country also.

## NOTES ON FAMILY

There are but two genera in North America that belong to this family, *Bolitophila* and *Palaeoplatyura*. *Hesperinus*, which has been placed here, possesses only 12 antennal joints and belongs to the Bibionidae. Johannsen expressed an opinion to this effect in his paper on the Mycetophilidae\*. The subfamily Mycetobiinae of Johannsen's paper is also, I am certain, composed of genera that are not closely allied. *Palaeoplatyura* very probably belongs to Bolitophilidae, where I have placed it, while *Ditomyia* and *Symmerus* should form a family by themselves. *Palaeoplatyura* is more closely related to *Bolitophila*.

\*The Fungus-gnats of North America, Pt. I, p. 222. (1910)

*ila* than to *Mycctobia*, as is evidenced by the complete media, and by the presence of the subcostal cross-vein in *P. johnsoni*. *Ditomyia* and *Symmerus* both lack the basal part of media and the subcostal cross-vein, while, in addition, the subcostal vein is incomplete. *Mycctobia* belongs to Rhyphidae.

There are two North American species of *Palaeoplatyura*, and four of *Bolitophila*,—two of which, *cinerea* and *hybrida*, occur also in Europe.

#### KEY TO GENERA

1. Medio-cubital cross-vein proximad of radio-medial, so that the 2 cells separated by basal portion of media are very unequal in length..... *Bolitophila*.
- Medio-cubital cross-vein almost in vertical line with radio-medial, so that the 2 cells separated by basal portion of media are almost equal in length..... *Palaeoplatyura*.

#### KEY TO IMAGINES OF BOLITOPIHLA MEIGEN

1. Fork of third vein ends in first branch of radius (Europe; N. Y.) ..... *cinerea* Meigen\*.
- Fork of third vein ends in costa..... 2
2. Anterior branch of cubitus discontinued some distance from base (Idaho; N. H.) ..... *disjuncta* Loew.
- Anterior branch of cubitus complete..... 3
3. Subcostal vein ends in costa at a point above or beyond the base of radial sector—third vein (N. H.; Ind.; B. C.) .. *hybrida* Meigen.
- Subcostal vein ends in costa at a point much proximad of base of radial sector (N. H.; N. Y.) ..... *montana* Coquillett.

#### KEY TO IMAGINES OF PALAEOPLATYURA MEUNIER

1. Wings unmarked; subcostal cross-vein absent (Wash.) ..... *aldrichi* Johannsen.
- Wings with grayish or fuscous markings; subcostal cross-vein present (Vt.) ..... *johnsoni* Johannsen.

\*The larva of *Bolitophila cinerea* has been figured and briefly described by Dr. Felt in the Twenty-ninth Report of the New York State Entomologist, p. 67. (1915)

#### Family MYCETOPHILIDAE

The limits of this family are somewhat doubtful, and the most recent papers on it seem to me to include a rather heterogeneous assemblage of genera that require considerable family subdivision. The

importance of certain structural details of the imagines is not sufficiently realized as yet, and as we gradually accumulate data upon the larval and pupal stages I am confident that certain groups at present considered as genera in the family will be elevated to subfamily, and some even to family, rank. I have taken upon myself the responsibility of separating some of the so-called subfamilies from Mycetophilidae—a step which I consider justified because of distinctions which are evident in the adult insects, and also in the known larvae and pupae.

#### FAMILY CHARACTERS

*Larva*.—Head complete, not very heavily chitinized, usually conspicuously different from the remainder of body in color; antennae usually short, appearing in many genera as pale rounded areas on each side of head near anterior margin; mandibles toothed; maxillae well developed, their inner surfaces usually conspicuously dentate; maxillary palpi developed or very slightly so; labium not in the form of a flat plate; median dorsal sclerite of head tapering to a point posteriorly. Ventral surface of thoracic and abdominal segments sometimes with a transverse band of black locomotor spinules, which are occasionally very conspicuous; prothoracic and first 7 abdominal segments each with lateral spiracles; apex of abdomen simple; anal spiracles terminal.

*Pupa*.—Head unarmed; antennae curving well over upper margins of eyes, forming a semicircle and ending about middle of wings along their costal margins. Thorax conspicuously elevated, the anterior margin almost vertical, the dorsum appearing in lateral view almost globose; spiracles not elevated; legs elongated; entire fore legs visible; mid coxae visible only in part; apices of all legs extending beyond apices of wings, those of the hind pair sometimes reaching apex of abdomen. Abdomen unarmed; 7 pairs of spiracles present, the basal pair usually hidden by wings.

*Imago*.—As limited in this paper this family contains only those genera that belong to the following subfamilies of Johannsen's paper on Mycetophilidae: Diadocidiinae, Sciophilinae, and Mycetophilinae. I consider that these three groups really constitute separate families, but in the absence of larval and pupal material as criteria I prefer to leave matters at present as they are, hoping at some future time to elucidate further their relation, or that some other student of the order may find time to do so.

## HABITS OF LARVAE

As the popular name, fungus-gnat, indicates, the larvae feed upon fungi in the great majority of cases. The species of fungi they attack and the situation in which the larvae are found differ very considerably. Many species feed upon *Agaricus* and allied genera in open situations; some feed upon *Polyporus* and other fungi growing upon living or dead trees; while others feed upon minute fungoid growths upon the under surfaces of fallen trees, rails, or boards upon the ground, and a few appear to live entirely upon vegetable matter in an advanced stage of decay. Nearly all the larvae spin webs in the galleries they make in their food; in the case of species that live externally upon fungi the web is slimy, rather loose, and irregular. I have paid particular attention to some species I have reared, and find that the larvae of this last group do not pass over the threads but through them, as in a tube, the body being enclosed except anteriorly. The threads are slimy in nature, and the presence of the larvae may be detected by the glistening surface of the fungus, which appears as if a slug had crawled over it. The larvae, as far as I have observed, spin a cocoon of a more or less compact nature to pupate in. In the case of *Leia* the pupa is simply suspended by means of a number of loose threads which keep it from the surface of the fungus or other matter in which it is found, and very probably safeguard it to some extent, as mites seem unable to cross the threads.

## HABITS OF IMAGINES

The imagines are found in a variety of situations, but most commonly in damp and rather dark places, especially where there is fungoid growth. Damp basements, old outhouses, and hotbeds, usually yield many species. In woods the greatest number may be obtained by sweeping amongst undergrowth in the most shady spots, though a number of species may be found on tree-trunks, where they run with surprising speed. Several species occur upon flowers, but the majority of them only in the late afternoon. Many species will on occasion feign death, but spring to life suddenly when touched. I have found specimens still enclosed within their loose silken cocoon when collecting under bark in spring. When touched the insects make a hurried exit only to feign death after progressing a few inches, and by means of alternate rushes and pauses they soon succeed in burying themselves under any loose detritus that is convenient.

## KEYS TO SUBFAMILIES

## LARVAE

1. Head usually deep black, only the antennal sockets and some small round spots pale; maxillary palpi not protruded..... *MYCETOPHILINAE*.
- Head pale, antennal sockets surrounded by a black band; maxillary palpi sometimes protruded (*Sciophila*)..... *SCIOPHILINAE*.

## PUPAE

1. Thoracic and abdominal respiratory organs sessile; slender species; legs and wings not closely fused together and to thorax..... *MYCETOPHILINAE*.
- Thoracic and abdominal respiratory organs elevated; robust species; legs and wings closely fused to each other and to thorax.... *SCIOPHILINAE*.

## IMAGINES

1. Medio-cubital cross-vein present; radius with 2 branches..... *DIADOCIDIINAE*.
- Medio-cubital cross-vein absent..... 2
2. Radius with 3 branches, the intermediate one connecting first and third usually near base of latter and forming a subquadrate or oblong cell..... *SCIOPHILINAE*.
- Radius with 2 branches..... *MYCETOPHILINAE*.

## Subfamily MYCETOPHILINAE

I have obtained the larvae and pupae of representatives of two genera of this subfamily. The larvae of these genera differ very markedly from each other though the pupae are very similar.

## SUBFAMILY CHARACTERS

*Larva*.—Head glossy black; antennae sessile; a conspicuous pellucid spot on each side of head below antennae; dorsal sclerite of head gradually tapered from before middle to posterior margin; maxillary palpi sessile, in the form of a rounded pellucid spot; entire inner margin of maxillae serrated; mandibles with 3 or more strong apical teeth, or with a continuous series of short teeth along one margin. Prothoracic and abdominal spiracles present. Locomotor organs indistinguishable or well developed, consisting, when present, of 2 transverse series of spinules on ventral segments.

*Pupa*.—More slender than pupa of Sciophilinae, and with legs and wings less closely adherent to each other and to thorax. The thoracic respiratory organs and the lateral abdominal spiracles are sessile; in *Leia* the basal abdominal segment has the spiracles rudimentary. The legs of the two genera are of different lengths.

#### HABITS OF LARVAE

The larvae of most genera of the subfamily are fungivorous, some feeding internally and some externally. Those that feed in the stems or other parts of fungi line their burrows with a slimy substance, while those that feed externally move inside of tube-like slimy threads.

#### HABITS OF IMAGINES

The imagines feed upon nectar and exuding sap of trees. They very frequently feign death when disturbed, and at other times squeeze themselves into very small cracks or openings in an effort to escape capture or injury.

#### KEYS TO GENERA

1. Locomotor spinules indistinguishable or very weak.....*Leia*.
- Locomotor spinules strong, black, forming a conspicuous transverse band on each ventral abdominal segment.....*Exechia*\*.

#### PUPAE

1. Legs quite dissimilar in length, apices of fore tarsi extending to base of fifth segment of abdomen, those of mid pair to apex of sixth, and those of hind pair to base of eighth.....*Leia*.
- Legs of nearly uniform length, terminating at apex of abdomen in a slightly concave transverse line.....*Exechia*.

#### LEIA Meigen

This genus contains a number of common and widely distributed species, which are usually conspicuously marked with black on a reddish yellow ground-color, and often have distinctly marked wings.

#### GENERIC CHARACTERS

*Larva*.—Head glossy black, much longer than broad, the posterior margin not excised; antennae very short and fleshy; pellucid spot be-

\*Some species of *Mycetophila* have locomotor abdominal spinules similar to those of *Exechia*, as described above. Osten Sacken figures the lateral cephalic sclerites of *Mycetophila signata* with rounded productions of their inner posterior extremities.

low antennae distinct; median dorsal sclerite pointed posteriorly. Thorax and abdomen without locomotor spinules; thoracic and abdominal spiracles distinct, the openings blackened.

*Pupa*.—Anterior margin of thorax declivitous; thoracic spiracles not elevated; antennae elongate, curved well over eye and ending about middle of wing; fore, mid, and hind legs ending at different distances from apices of wings; abdomen without noticeable armature.

#### HABITS OF LARVAE

The larva lives in a loose slimy web on damp rotten wood or on fungus, and the pupa is found suspended in the threads. The larvae are very active, moving within the slimy tubular thread, either forward or backward, with great facility, and in their behavior resembling some tortricid larvae of the Lepidoptera.

#### HABITS OF IMAGINES

The imagines closely resemble those of *Mycetophila* and are found in the same situations—sometimes on flowers, on windows, or under logs, and not uncommonly at lights. I have found *L. oblectabilis* in hundreds on the walls and windows of the Natural History Building here in July and August.

#### LEIA OBLECTABILIS Loew

*Glaphyroptera oblectabilis* Loew, Berl. Ent. Zeitschr., 1869, p. 146.

*Larva*.—Length, 11–13 mm. White, semitransparent; head glossy black.

Median dorsal sclerite of head tapering gradually from before middle, ending in an acute point at posterior margin (Pl. XXXVII, Fig. 1); antennae not elevated, represented by rounded, pale, membranous areas; pellucid spot below antennae large and rounded; mandibles with 3 large teeth and 2 small ones on outer margin, and 3 or 4 on inner surface (Pl. XXXVII, Fig. 10); maxillae serrate on inner margin, the palpi not well-developed (Fig. 13); ventral surface of head as in Figure 14 of plate mentioned, the posterior excision cordiform; hypopharynx as in Figure 8. Prothoracic and abdominal spiracles small, the latter especially so. Abdomen glabrous, no locomotor organs distinguishable.

*Pupa* (Pl. XXXVII, Fig. 5).—Length, 5–6.5 mm. White, becoming darker and showing the markings of the imago as the latter nears emergence.

Head without protuberances; antennae extending beyond base of wing; palpi straight, directed laterad; wings extending slightly beyond base of fourth abdominal segment; fore tarsi extending to base of fifth, mid pair to base of seventh, hind pair to base of eighth. Abdomen glabrous; 6 pairs of well-developed lateral spiracles present, basal pair rudimentary.

Described from a number of specimens obtained by myself at White Heath, Savoy, and Urbana, Ill., in June, July, and September, 1915-16.

#### EXECHIA Winnertz

As I have but one species of this genus represented by other than the imaginal stage, the generalization for the larval and pupal stages may not apply to all species of the genus.

#### GENERIC CHARACTERS

*Larva*.—Head not much longer than broad, posterior margin with a central and medio-lateral excision on dorsum; central plate tapered gradually from before middle, ending in a rounded point at posterior margin; antennae sessile; pellucid spot below antennae distinct; mandibles rounded, with numerous short teeth; maxillae normal, their palpi larger than those of *Leia*; ventral excision as in that genus. Body with locomotor organs on venter, each consisting of 2 transverse series of black spines; spiracles conspicuous, the prothoracic pair slightly elevated and with 4 openings.

*Pupa*.—Similar to the pupa of *Leia*, but differing in the length of the legs.

#### HABITS OF LARVAE

The larvae are fungivorous, feeding usually in the stems of mushrooms. They commonly line their burrows in the stems with a slimy fluid similar to that excreted by *Leia*. Pupation takes place in the burrows.

The species which I have reared, or attempted to rear, are often killed by a hymenopterous parasite when on the point of pupation.

#### HABITS OF IMAGINES

The species frequent woods, especially the denser parts, and may often be taken in great numbers about fungi. They very often occur

on the windows of houses, particularly in the evening, and they are readily attracted to lights.

In Britain many species of this and allied genera occur during winter in clumps of grasses and ferns overhanging streams and ditches, and this fact seems to indicate that they hibernate as adults.

### EXECHIA NATIVA Johannsen

*Exechia nativa* Johannsen, Bull. 200 Maine Agr. Exper. Station, p. 70. (1912)

*Larva* (Pl. XXXVII, Fig. 3).—Length, 8–9 mm. White, head and locomotor spinules black.

Head as in Figure 7, Plate XXXVII; mandibles different from those of *Leia* in having 9 sharp teeth distributed along their entire outer margin (Fig. 6); maxillary palpi much longer than in *Leia* (Fig. 9); hypopharynx as in Figure 11. Thoracic spiracles each with 4 slit-like openings (Fig. 4); abdominal pairs smaller than the thoracic. Locomotor spinules arranged as in Figure 2, Plate XXXVII, the apices of the spinules in the anterior and posterior series directed respectively cephalad and caudad.

*Pupa* (Pl. XXXVII, Fig. 12).—Length, 4–6 mm. Color at first like that of larva, but later becoming darker, and just before the emergence of the adult the color of the latter is clearly discernible through the pupal skin.

Head unarmed, slightly more retracted than in *Leia*; antennae extending beyond middle of wings; palpi directed straight laterad. Thoracic respiratory organs sessile; wings extending to middle of fourth abdominal segment; legs extending to apex of abdomen, ending in an almost straight transverse line. Abdomen without armature; spiracles slightly elevated.

Described from specimens I collected from the stems of a species of *Agaricus* in the forestry of the University of Illinois, at Urbana, in September, 1915.

The effect of parasitism upon the pupa is shown in Figure 15, Plate XXXVII, the larval skin having been shed but the formation of the pupa prevented.

### Subfamily SCIOPHILINAE

This subfamily is unknown to me in the immature stages except by the larval exuvium and the pupae of one species and from published descriptions of the larvae of others. The tracheal system of

*Sciophila*, as described by several writers, corresponds with that of *Leia* and *Erechia*, as well as with other described genera of Mycetophilinae, in having lateral openings on abdominal segments 1-7. There is however an illustrated published description by Schmitz of the larva of a European species of *Polylcpta* that shows no abdominal spiracles. I have not the larva of *Polylcpta*, which appears to form a connecting link between this subfamily and Platyyuridae. Osten Sacken states that the abdominal spiracles in the species of *Sciophila* known to him were very small, which would seem to indicate a step towards their ultimate elimination as functional organs. Dufour's description and figures of a species of the same genus represent the spiracles as large, the thoracic pair bifid. I have only an exuvium, and give no data on this point.

#### CHARACTERS OF SUBFAMILY

*Larva*.—Head elongate; maxillary palpi well developed in *Sciophila* only; cephalic sclerites contiguous medianly on anterior half of their ventral surface, but widely separated on the posterior half. Body very slender; spiracles present on abdominal segments in *Sciophila*, absent in *Polylepta*.

*Pupa*.—Stout. Head without protuberances; palpi curved forward on their apical halves; antennae curved over upper margin of eyes, extending to middle of wing. Thorax declivitous anteriorly; respiratory organs slightly elevated; wings extending to apex of third abdominal segment; legs parallel, the tips of tarsi reaching to apex of seventh abdominal segment. Abdominal spiracles slightly elevated, absent on first segment in species before me.

*Imago*.—Distinguished from Mycetophilinae by the furcate third vein, the anterior branch leaving the posterior at right angles and joining the second vein in similar manner, thus forming a subquadrate or elongate closed cell.

#### POLYLEPTA Winnertz

The larva of one species of this genus, which occurs in caves in Europe, has been described by Schmitz\*. This species, *P. leptegaster*, has been recorded from North America, and a summary of the description is given herewith as the original publication is not generally available in this country.

As indicated previously, the larva has no lateral abdominal spiracles, which is at variance with the rule in Mycetophilidae.

\*Naturhist. Genootschap in Limburg, Jaarboek, 1912, 4th Note.

## POLYLEPTA LEPTOGASTER Winnertz

*Polylepta leptogaster* Winnertz, Verh. zool.-bot. Ges., Vol. 13, p. 746. Imago. (1863)

*Larva*.—Length, 10 mm. Body worm-like, long and slender, in the middle cylindrical, tapering towards extremities. Functional spiracles present on prothorax only, the tracheal trunks confined to the first 2 thoracic segments, terminating on each side at posterior margin in 2 closed functionless spiracles. Head elongate (Pl. XXXVIII, Fig. 3); antennal sockets surrounded by a chitinized dark band, the antennae rudimentary; maxillary palpi not protruded as figured by Osten Sacken for *Sciophila*, their apices extending very slightly beyond apices of the serrated maxillae; mandible with 5 teeth, the upper one strong, the others becoming progressively weaker to lower one (Pl. XXXVII, Fig. 16); median opening in posterior half of ventral surface of head cordiform. Abdominal locomotor organs very weak.

*Pupa*.—Undescribed.

This species has been recorded from New Hampshire and Indiana. Schmitz's specimens were obtained in a cave in Europe.

Johannsen records 4 species of the genus from North America.

## MYCOMA BREVIVITTATA Coquillett

*Sciophila brevivittata* Coquillett, Jour. N. Y. Ent. Soc., Vol. 13, 1905, p. 67.

*Mycoma brevivittata* (Coquillett) Johannsen, Bull. 180, Maine Agr. Exper. Station, p. 176. (1910)

*Larva* (exuvium).—Head as in Figures 1 and 4, Plate XXXVIII; maxillary palpi short, not surpassing the apices of maxillae; antennae not protruded, the antennal socket surrounded by a black band; mandibles with a double series of teeth, which are very unequal in size (Pl. XXXVII, Fig. 17); median dorsal sclerite of head tapering to a point posteriorly. Tracheal trunks large; prothoracic spiracles distinct; no other spiracles discernible in specimen, but they are rarely visible in exuvia though they may be present in the larva; locomotor spinules not distinguishable.

*Pupa* (Pl. XXXVII, Fig. 18).—Length, 4-5 mm. Brown, slightly shining; enclosed in a silken web.

Stout; anterior margin of thorax vertical, head not extending to anterior margin of thorax; antennae curved over upper margin of eyes and extending to middle of wing, their bases rounded in profile; palpi not extending to upper eye-margin. Thoracic respiratory organs elevated; surface of thorax with short sparse setulae; wings, antennae,

and legs closely fused to thorax; wings extending to apex of third segment or slightly beyond it; legs extending to apex of seventh segment, their apices forming a slightly concave transverse line. Abdomen with numerous microscopic dorsal setulae; spiracles of first segment obsolete, those on segments 2-7 elevated; metanotum centrally concave anteriorly, so that its length at center is about half that of first abdominal segment, while laterally it is as long as the latter; second segment longer than any of the others; seventh about half as long as sixth; eighth and ninth segments combined equal in length to sixth.

The foregoing descriptions were made from a larval exuvium and pupae, the species being obtained by me in the Augerville woods near Urbana, Ill., June 23, 1916. The larvae were feeding on a fungus growing upon the under side of a log lying upon the ground.

The principal differences between this species and *Polylepta leptogaster*, exclusive of any that may exist in the respiratory system, lie in the structure of the mandibles and of the maxillae, and in the absence of locomotor spinules. Schmitz figures the cephalic dorsum as entire in *Polylepta*, which may be an error.

#### Family SCIARIDAE

The members of this family have until recently been classed as a subfamily of Mycetophilidae, but in this paper and in some papers by other authors they are accorded family rank. There is a striking uniformity of structure in the imagines of *Sciara*—the genus that contains by far the largest number of the included species—and in the larvae known to me there is also a striking similarity in appearance and structure. I have reared but few species, and my generalizations are based upon these.

#### FAMILY CHARACTERS

*Larva*.—Head like that of Mycetophilinae, differing principally in having 2 narrow bands of chitin connecting the lateral sclerites on their ventral surface (Pl. XXXVIII, Fig. 2), in having the median dorsal sclerite distinctly and often rather abruptly constricted at or slightly beyond middle (Pl. XXXVIII, Figs. 6, 9), and in the absence of the clear spot below antennae. The mandibles are almost quadrate in outline, have 3 large apical teeth, and usually 2 or 3 smaller ones at inner angle of apex (Pl. XXXVIII, Fig. 14). The general shape of the head in species known to me is subquadrate (Pl.

XXXVIII, Fig. 6). In other respects the larvae closely resemble those of *Leia*, the locomotor organs when present being inconspicuous and the abdominal spiracles black and easily distinguished.

*Pupa* (Pl. XXXVIII, Figs. 5, 7).—General appearance similar to that of pupae of Mycetophilinae, but differing noticeably in having the thorax much less swollen and not declivitous anteriorly, the antennae much longer, frequently extending to apices of wings, and the fore, mid, and hind legs of conspicuously different lengths, and noticeably shorter than in Mycetophilidae. The abdomen is sometimes furnished with short setulose hairs and has 6 pairs of exposed spiracles as have *Leia* and allied genera, the basal (seventh) pair very small and discoverable only by careful examination and partial dissection of base of abdomen. The legs in many species are very much shorter than in *Sciara prolifica*, which is the species figured, the hind pair sometimes reaching only to apex of fourth segment. The abdomen also lacks the short setulae that are present in *prolifica*.

#### HABITS OF LARVAE

The larvae are essentially scavengers, feeding upon decaying vegetable matter, and manure, but some species do considerable damage to cultivated mushrooms, and under natural conditions feed on fungi. Occasionally in early spring some species appear in immense numbers in plant-propagating houses, having been introduced in leaf-mold in very late fall or in winter while in the egg or larval stage.

Some species, usually when full-grown, have a peculiar habit of leaving the place where they have fed and traveling on the surface of the ground in a rope-like aggregation, which may attain a diameter varying from an inch to three inches and a length of eighteen inches to five feet and contain several thousand larvae. Some European authors give the size of these ropes as three to four inches wide and twelve to fourteen feet long. This habit has long been known in Europe, and has given the larva the names "rope-worm", "snake-worm", and "army-worm". A few records of this habit in America have appeared, the last I know of being in my paper in the preceding volume of this bulletin.\*

This office has on file records of these larvae feeding upon dead white-grubs that were killed by fungi or bacteria.

Some species form a slight shiny tunnel-way in which they live, but it is difficult to detect it in most cases.

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\*Vol. 11, Art. IV, p. 320. (1915)

## HABITS OF IMAGINES

The imagines have much the same habits as Mycetophilidae, but I have rarely seen them feign death as do the imagines of *Cordyla* and *Mycetophila*. *Eugnoriste*, which has a very long proboscis, is commonly found on flowers of *Erigeron* and similar plants. Most species of *Sciara* are common on plants and assumably feed on nectar.

Family *MACROCERIDAE*

I have not found the early stages of any species of this family, and consequently can not include it in my keys to the larvae and pupae.

The species are generally rare in North America, but in Europe several occur rather commonly, especially under overhanging banks of streams in or near woods. In early spring they may be beaten from such banks, where grass or ferns overhang their edges, and from the fact that I have taken some species very late in the fall and again early in the spring I assume that they hibernate in the adult stage.

There is but one genus in the family, twelve species of which are listed by Johannsen. Three species are known to occur in Illinois.

Family *PLATYURIDAE*

## FAMILY CHARACTERS

*Larva*.—Head subquadrate, the labrum slightly protruded; antennae very short; mandibles serrate; maxillary palpi sessile; maxillae serrate; median dorsal sclerite of head not tapering to a point posteriorly. Thorax and abdomen without distinguishable spiracles, the latter with a pair of protrusive blood-gills on apical segment; all segments with a number of flat transverse ridges separated by rather deep and very narrow depressions; entire body slightly flattened and with a narrow lateral extension each side which is crossed by ridges as is the dorsum.

*Pupa*.—Head more protruded than in Mycetophilidae; antennae broad, projecting upward and backward in a straight line, ending near base of wing. Abdominal spiracles elevated; legs long, the apices of hind pair extending to apex of abdomen.

## HABITS OF LARVAE

The larvae live in slimy webs on fungi, usually on the under surface of such as grow upon fallen or decaying timber. They move

freely, usually within the tube-like threads, and frequently turn completely around in these, moving along with a gliding effect. They do not move very rapidly when taken from the webs, and are very fragile. Before pupation they spin an elongate cocoon, which is rounded at each end and consists of rather coarse outer threads and a complete inner gelatinous envelope. To the surface of this inner covering, threads leading from the body are attached, these serving as a means of suspension for the pupa. How the larval skin can possibly be shed without detaching these threads I can not explain, but it is done. The cocoon is itself suspended in a mass of rather loose threads and forms a very pretty object when bedecked with tiny drops of moisture, as it usually is in the damp situations where the species occur.

All the examples that I removed from the cocoons died in the pupal stage—whether because of handling or from other causes I do not know.

#### HABITS OF IMAGINES

The imagines of this family are taken more frequently upon flowers than are those of Mycetophilidae, and they are not uncommon in shady places in woods and amongst long grass on railroad embankments, especially where old railroad ties are lying.

#### CEROPLATUS Bosc

I have obtained the larvae of two species which I believe belong to this genus and also the pupa of one, but unfortunately failed to rear the species to maturity. The characters possessed by the larvae are summarized herewith. The larva and pupa of a European species (*sesioides* Wahlberg) are phosphorescent.

#### GENERIC CHARACTERS

*Larva*.—Semitransparent, white, variously marked with purple. Head as in Figures 10, 11, and 15. Plate XXXVIII; mandibles and maxillae as in Figures 12 and 8. Body slightly flattened dorso-ventrally, the lateral margins slightly produced, somewhat bead-like. Thoracic markings consisting of an irregular longitudinal stripe along sides mesad of the lateral production, and usually a less clearly defined narrow posterior band along the hind margin of each segment. Abdominal segments with a dark band on each of the elevated transverse ridges on each segment, the dark color ceasing

a short distance from the lateral production. In one species the bands are almost uniform in color, but in the other there is a darker spot on each extremity of the posterior band, and there are 5 slight but appreciable interruptions in the dark stripes, giving the dorsum the appearance of having 6 dark longitudinal stripes. The species which has the uniform transverse dorsal abdominal stripes has 5 transverse dark stripes on the ventral surface of each segment, the penultimate one of each series very narrow; the other species has 4 such transverse stripes, and in addition a distinct median longitudinal stripe. The apical segment in both species is as in Figure 13; the lateral pointed blood-gills are retractile.

*Pupa* (Pl. XXXVIII, Fig. 16).—Entire body without armature, the skin very thin.

Antennae much flattened, their anterior margin produced beyond the anterior margin of thorax. Thoracic respiratory organs sessile; scutellum protuberant; anterior margin of thorax sloping; wings extending to apex of third segment of abdomen; fore tarsi extending to apex of seventh segment, mid pair to apex of abdomen, hind pair reaching slightly beyond apex. Abdomen unarmed; seven pairs of spiracles present.

The foregoing descriptions are based upon examples obtained by the writer at White Heath, Ill., June 24 and 25, 1916. I did not observe indications of phosphorescence in the larval and pupal stages, but made no effort to determine whether it existed, owing to my failure to note the European record until too late to verify it.

#### PRINCIPAL PAPERS ON NORTH AMERICAN MYCETO PHILOIDEA

Johannsen, O. A.

'09-'12. The fungus gnats of North America. Parts 1-4. Bull. Maine Agr. Exper. Station, Nos. 172, 180, 196, 200. (Includes all families in my superfamily Mycetophiloidea under Myeetophilidae.)

Osten Sacken, C. R.

'62. Characters of the larvae of Mycetophilidae. Proc. Ent. Soc. Phila., 1: 151-172. (Includes all the families of my Myeetophiloidea, and gives references to previous literature on life histories of the species.

Schmitz, H.

'12. Biologisch-anatomische Untersuchungen an einer höhlenbewohnenden Mycetophilidenlarve, *Polylepta leptogaster* Winn. Natuurhist. Genootschap in Limburg Jaarboek, 1912, 4th Note. (This species occurs in the United States.)

## Superfamily *Culicoidea*

This superfamily includes the following families according to the present arrangement: Psychodidae, Blepharoceridae, Culicidae, and Dixidae. The last family has been considered by some writers as a subfamily of Culicidae. There are, however, very marked differences between the corresponding stages of Culicidae and Dixidae which I believe warrant their recognition as distinct families.

### SUPERFAMILY CHARACTERS

*Larva*.—All the larvae of the group make primary or exclusive use of the anal spiracular appendages for respiration, Culicidae making exclusive use of them except in a very few cases. The larvae of this family are distinguished from those of any allied family by the fusion and very noticeable expansion of the thoracic segments. Many larvae of the subfamily Corethrinae (Culicidae) are remarkably specialized in having air-sacs in the thorax and near apex of abdomen, which show as blackish spots, and are without the elongate anal respiratory tubes of the normal forms of the Culicinae. These larvae are sometimes found at great depth in lakes, under anaerobic conditions. The larvae of Blepharoceridae have the thoracic and first and second abdominal segments fused and the head poorly differentiated. The lateral abdominal spiracles in this family are not functional. Some Psychodidae have larvae that superficially resemble those of Blepharoceridae in general form, even having median ventral sucker-like discs on abdomen as that family has; but the thoracic segments are not so closely fused, the head is well differentiated, and the apical segment has a more or less elongated respiratory tube instead of its being rounded. The larvae of Dixidae in general appearance resemble those of Chironomidae, but they differ from the latter in having pseudopod-like protuberances on dorsum of basal two abdominal segments, and the head differs greatly from that of Chironomidae. These characters, in my opinion, taken in conjunction with those of the wing of the adult, associate this family more closely with the Culicidae than with the Chironomidae.

*Pupa*.—The thoracic respiratory organs are elongated in all families of Culicoidea. The pupae of Culicidae and Dixidae have the legs recurved against the ventral surface of the base of the abdomen so that they scarcely protrude beyond the apices of the wings. The legs in Psychodidae and Blepharoceridae are straight, but do not extend beyond apices of wings, or, at most, but slightly beyond. For other

differentiating characters see key to pupae of Nematocera and descriptions of families.

*Imago*.—Mouth parts sometimes fitted for piercing, rarely aborted; palpi sometimes remarkably long; antennae from 9- to 15-jointed, often with long plumes or with whorls of hairs; ocelli absent or present. Thorax without complete, well-defined suture. Wings without discal cell; surface often haired or scaled; costa, in all except Blepharoceridae, encircling wing, in the latter the field of wing has numerous longitudinal and transverse creases which give it the appearance of having a secondary venation. Legs very slender except in Psychodidae; in the latter and in most Culicidae, with conspicuous hairs or scales.

### Family PSYCHODIDAE

#### FAMILY CHARACTERS

*Larva*.—Head complete; antennae protuberant; mandibles opposed, toothed, sometimes with long, fringed outer processes; labium usually serrate on anterior margin. Prothorax with distinct spiracles, sometimes protuberant; thoracic and first abdominal segments with a slight central transverse constriction, giving them a biannulate appearance, remaining abdominal segments, except the apical one, triannulate; some of the abdominal segments usually with a chitinized dorsal plate upon each of the annuli; in some cases all the segments of thorax and abdomen have such plates, some of those on thorax being interrupted longitudinally in center to facilitate the rupturing of the skin for the exclusion of the pupa; apical abdominal segment usually more or less elongated, particularly in the species without or with very few dorsal plates, in the form of a tapering tube, chitinized, the pair of tracheal spiracles opening close together at its apex, generally with 4 protuberances which are fringed with soft hairs; surface of body with moderately long bristly hairs, variously arranged in the different species.

*Pupa*.—Prothoracic spiracles elevated, stalk-like; head parts, legs, and wings distinct, closely adherent to body; fore tarsi overlying mid pair, the latter overlying hind pair; apices of hind legs not projecting beyond apices of wings. Dorsal appearance of body in *Maurina* oval in outline, without a distinct break at base of abdomen; the dorso-ventral elevation very slight, so that the pupa appears somewhat in the form of an oval scale (onisciform) without projecting spines or bristles on dorsum. In *Pericoma* and *Psychoda* the pupa is much like that of a small tipulid, but the legs are very much shorter and the wings are differently shaped.

*Imago*.—Wings broad and short, generally oval in outline, with long and dense surface hairs; entire body and legs with long hairs; antennae with pedunculate joints, each joint with a whorl of hairs, joints 12 to 16 in number; palpi 4-jointed.

#### HABITS OF LARVAE

The larvae of *Psychoda* are found in cow dung, decaying vegetable matter, exuding sap on tree-trunks, fungi, and in putrid water; those of *Pericoma* are found in shallow slow-flowing water or in tree-holes; *Maurina* has only been recorded from situations where the water had a rather swift flow, and it is evidently adapted to this sort of habitat by the presence of suckers on the ventral surface of the abdomen.

The food of the larvae consists of algae and decaying vegetable matter.

#### HABITS OF IMAGINES

The imagines may usually be found in large numbers in close proximity to the larval pabulum, and are very common on windows in outhouses or in houses that have damp cellars, or where there are cesspools or cisterns. Rather dark, damp situations are particularly favorable to the species in any stage. The flies may be found in great numbers at lights at night. Many species of *Pericoma* are found upon tree-trunks in the daytime.

The food of the imago consists of nectar or fluid matter in the genera *Pericoma* and *Psychoda*, but the species of *Phlebotomus* are blood-suckers, feeding upon the blood of various reptiles, amphibians, and mammals—including man. Some species act as vectors of diseases of man, papataci fever and verruga being transmitted by species of *Phlebotomus*. Taylor has described a species from Australia, under the name *Pericoma townsvilensis*\*, which he records as a blood-sucker. It is not possible to decide as to the generic status of the species, but his figure shows it to be either a *Psychoda* or a *Phlebotomus*—probably it is the latter.

#### KEYS TO GENERA

##### LARVAE

1. Ventral abdominal segments with median sucker-like disc; thoracic segments with larger chitinized plates than the following abdominal segments. .... *Maurina (Pericoma) californiensis*.

\*Bull. Ent. Research, Vol. 1, Pt. 3, 1915, p. 267.

- Ventral abdominal segments without median sucker-like disc; thoracic segments without chitinized plates, or if these are present they are not noticeably larger than those on the following segments..... 2
- 2. Apical abdominal segment short and stout, with 4 small protuberances which are fringed with soft hairs..... *Pericoma*\*.
- Apical abdominal segment usually conspicuously elongated, in the form of a chitinized tube; apical protuberances and fringes short ..... *Psychoda*\*.

#### PUPAE

- 1. Pupa flattened, about twice as long as broad, oval in outline, the abdomen laterally not narrower than the thorax, without spines, apical segment rounded..... *Maurina (Pericoma) californiensis*.
- Pupa not flattened, more than 3 times as long as greatest breadth, abdomen well differentiated from thorax and with transverse series of spines, apical segment not rounded..... *Pericoma* and *Psychoda*†.

#### MAURINA (PERICOMA) CALIFORNIENSIS Kellogg

*Pericoma californensis* Kellogg, Ent. News, Vol. 12, 1901, p. 46. Larva and pupa.

*Pericoma californica* Kincaid, Ent. News, Vol. 12, 1901, p. 195. Imago.

The above synonymy is the reverse of that given in Aldrich's Catalogue, but must be accepted because of the following facts. It is sufficient for the purpose of identifying a species that either the larval or pupal stage be accurately or recognizably described; Kellogg described and figured both larva and pupa and described the habits of the species in February, whereas the description of the adult by Kincaid did not appear until the following September. The fact that Kellogg gives Kincaid as authority for the name *californica* in the legend to his figures of larva and pupa does not alter the status of *californiensis*, for Kincaid's name, *californica*, had no standing until published by him in September; and that he was in no way responsible for either Kellogg's descriptions or figures seems evident from the absence of acknowledgment to that effect in Kellogg's paper.

\*The last two genera are separated by the use of characters that appear to apply very well to the groups as far as they are known, but within the composite genus *Psychoda* there are larvae that differ in such degree as to warrant their further subdivision.

†I know of no reliable characters that can be used in the separation of the pupae of *Pericoma* and *Psychoda*. My material is confined to the latter, a key to part of which is given herewith.

The generic name *Maurina* was first used by Müller for a group of 3 species found by him in southern Brazil in situations similar to those in which *californiensis* occurs—rather swift running water\*. The larvae agree with the larva of *californiensis* and differ from others belonging to *Pericoma* in having a medio-ventral series of sucker-like discs, one on each abdominal segment except the last, and the pupae, with their oval shape and flat appearance, conform to the same grouping. Eaton has subdivided the genus *Pericoma* into several genera, but upon adult characters only.

I have not seen any stage of *californiensis*, no suitable situations for its occurrence being in this part of the state.

The wing venation of the imago as figured by Kincaid differs from that of the normal *Pericoma*, and in the absence of the base of the anterior branch of the posterior furcate vein resembles that given by Müller for the Brazilian species.

### PSYCHODA Meigen

#### KEYS TO SPECIES

##### LARVAE

1. Thorax without well-defined chitinized transverse plates.....	2
— Thorax with well-defined chitinized plates.....	6
2. Abdomen without chitinized dorsal plates.....	<i>minuta</i>
— At least sixth and seventh segments with chitinized dorsal plates ..	3
3. Sixth and seventh abdominal segments each with 3 chitinized transverse dorsal plates.....	4
— Fifth, sixth, and seventh abdominal segments with chitinized transverse dorsal plates.....	5
4. Thoracic and abdominal segments, except sixth and seventh, each with a closely approximated pair of hairs on a small circular plate near the posterior lateral margin.....	<i>nocturnala</i>
— Thoracic and abdominal segments without such hairs†.....	<i>schizura</i>
5. Fifth, sixth, and seventh abdominal segments each with 3 chitinized transverse dorsal plates.....	<i>albimaculata</i>
— Fifth and sixth abdominal segments each with 3 chitinized transverse dorsal plates, seventh with 2.....	<i>floridica</i>
6. Prothoracic segment with one chitinized plate, metathoracic segment with 2 such plates; abdominal segments, except 6 and 7, without chitinized plates.....	<i>alternata</i>
— Each thoracic and abdominal segment with a chitinized plate on each annulus.....	7

\*Trans. Ent. Soc. London, 1895, p. 480.

†Neither mentioned in description nor drawn in figures by Fullaway, so assumed to be absent.

7. All chitinized plates with several long and conspicuous bristles; apical respiratory tube short and stout (Pl. XXXIX, Fig. 8) ... *superba*.  
 — Chitinized plates with at most very inconspicuous bristles; apical respiratory tube very distinctly elongated and tapering apically. 8

8. Robust species; basal abdominal segment with narrow transverse chitinized plates.....sp. ?

— Slender species; basal abdominal segment with spot-like chitinized plates.....*cinerea*\*.

## PUPAE

1. Ventral abdominal segments each with 3 transverse series of spinules, the anterior and posterior marginal series compact, the one on middle of segment consisting of 4 widely separated spinules.....*minuta*.  
 — Ventral abdominal segments each with 2 transverse series of spinules, the widely separated median series and the compact posterior marginal one.....2

2. Prothoracic respiratory organs as long as greatest width of thorax; first 2 ventral abdominal segments beyond apex of wings each with 2 spinules in median transverse series.....*alternata*.

— Prothoracic respiratory organs much shorter than greatest width of thorax; at least the second ventral abdominal segment beyond apex of wings with 4 spinules in median transverse series.....3

3. Prothoracic respiratory organs with groups of openings, not with a continuous series on surface; second dorsal abdominal segment with distinct apical transverse series of spines, the series on segments 3 to 7 with a pair of single long spines close to middle, and another between these and lateral extremity of series, the latter paired (Pl. XXXIX, Fig. 4) .....*superba*.

— Prothoracic respiratory organs with continuous series of openings, not groups; abdominal armature not as above.....4

4. First ventral abdominal segment beyond apices of wings with 2 spinules in median transverse series.....*albimaculata*.

— First ventral abdominal segment beyond apices of wings with 4 spinules in median transverse series.....*cinerea*.

## PSYCHODA MINUTA Banks

*Psychoda minuta* Banks, Can. Ent., Vol. 26, 1894, p. 331.

*Larva* (Pl. XXXIX, Fig. 7).—Length, 2.75-3 mm. Whitish testaceous, apex of anal respiratory tube dark brown.

Head distinctly longer than its greatest width; maxillae prominent, their palpi protruded, fringed; antennae very minute. Pro-

\*See remarks in text under *domestica*.

thoracic spiracles slightly elevated; second annulus of segment with indications of a dorsal plate; remaining thoracic and abdominal segments without dorsal plates; divisions between thoracic and abdominal segments distinct, the annuli very poorly defined; surfaces of both thoracic and abdominal segments densely covered with very short pale hairs, the only distinguishable setulose hairs being on lateral margins of posterior annuli of segments. Apical abdominal segment tube-like, chitinized but not conspicuously darker than preceding segments, its length about 3 times as great as its greatest width; apical papillae very small, fringes short (Fig. 9).

*Pupa*.—Length, 2 mm. Yellowish testaceous.

Prothoracic organ (Pl. XXXIX, Fig. 5) of moderate size, tapering apically, and with a series of small spiracle-like protuberances along one side; eyes large; antennae considerably thickened (male); front view of head and appendages as in Figure 16. Abdominal armature weak; dorsal segments, except basal, each with a transverse posterior series of widely separated spinules and an interrupted median series of very minute setulae (Fig. 17); ventral segments (Fig. 18), except the apical one and those below wings, each with a posterior and anterior transverse series of closely placed spinules and a median transverse series of 4 rather widely placed spinules; apical segment with 3 spines on each side, the two lower ones very closely placed; apical thorns on upper margin strong (Fig. 1).

The above descriptions were drawn from larvae and pupae obtained from cow dung in November, 1915, and April, 1916, the former at Urbana and the latter at White Heath, Ill.

The small size of this species makes it a very difficult one to rear and isolate the stages and exuvia successfully.

Originally described from Sea Cliff, N. Y., and subsequently recorded from Mesilla, N. Mex. Probably of general occurrence throughout North America.

#### PSYCHODA SUPERBA Banks

*Psychoda superba* Banks, Can. Ent., Vol. 26, 1894, p. 332.

*Larva* (Pl. XXXIX, Fig. 13).—Length, 5-5.5 mm. Grayish white; head, chitinized dorsal plates, and apical segment brown.

Dorsal surface of head with several long hairs; antenna terminating in 2 stout bristles and 2 weak hairs (Fig. 12). All thoracic and abdominal segments with a single large chitinized plate on dorsum of each annulus, those of prothoracic and first mesothoracic annuli

narrowly interrupted on middle line; prothoracic spiracle elevated, the protuberance nearly twice as long as thick. Membranous portions of thorax and abdomen covered with numerous very short spinules; chitinized plates on dorsum with a number of long hairs and many short spines (Fig. 8); anterior and posterior annuli of abdominal segments each with long lateral hairs, the median one with a short, stout lateral protuberance which has the appearance of a rudimentary spiracle; ventral segments with a transverse series of long hairs on each of the intermediate (4) and posterior (4-6) annuli, those on the former inserted in small round dark plates; apical segment about 1.5 as long as wide, armed with a number of dorsal and lateral hairs, ventral surface with a large chitinized plate, the rounded apex of which is armed with a fringe of long stiff hairs; laterad of this plate and near its margin is a small rounded plate upon which are 2 long hairs; apex of segment above terminating in 4 short clubbed processes which are fringed with a number of long radiating hairs (Fig. 15).

*Pupa* (Pl. XXXIX, Fig. 10).—Length, 3.5 mm. Brownish testaceous, not shining.

Prothoracic respiratory organs (Fig. 6) slightly tapering at base and apex, surfaces honeycombed or shagreened and with a number of small tracheal openings. Ventral aspect of pupa as in Figure 10, the transverse abdominal armature in 2 rows on each segment, the anterior row consisting of 4 widely placed spinules on disc and one on each lateral margin, the posterior row of numerous closely placed spinules, the apices of some of which are irregularly dentate; dorsal segments, except basal, each with a single transverse series of spinules on posterior margin which is similar to that on ventral segments, and also, like that series with 4 longer hairs (Fig. 4); apical segment with the upper posterior margin armed with 2 very short thorns, the lower posterior margin with 2 long, curved thorns (Fig. 2).

The foregoing descriptions are drawn from larval and pupal material obtained from water in a tree-hole in the forestry of the University of Illinois at Urbana June 2, 1916. The duration of the pupal stage averaged three days under laboratory conditions.

The species was originally described from imagines obtained at Sea Cliff, N. Y., and has been recorded from Battle Creek, Mich. I took imagines on tree-trunks at Urbana in July and August, 1915.

The larva bears a striking resemblance to that of *Pericoma canescens* Meigen as figured by Miall and Walker\*, but differs in the ar-

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\*Trans. Ent. Soc. London, 1895, Pl. III.

angement of the hairs both on the dorsal plates and on the ventral surface, and also in the form of the apical segment. There are no outstanding differences in the pupae of the two species.

#### PSYCHODA DOMESTICA Haseman

*Psychoda domestica* Haseman, Ent. News, Vol. 19, 1908, p. 282.

The immature stages of this species were described by Haseman. I suspect that the species is a synonym of *cinerea* Banks. The only difference between the larva described by Haseman and that described as *cinerea* in the present paper lies in the absence of the small plates on the basal abdominal segment in *domestica*. These are difficult to see in fresh material, and may have been overlooked by Haseman.

Described from specimens obtained from plant cultures in a laboratory at Columbia, Mo.

#### PSYCHODA CINEREA Banks

*Psychoda cinerea* Banks, Can. Ent., Vol. 26, 1894, p. 330.

*Larva* (Pl. XXXIX, Fig. 11).—Length, 4.75–6 mm. Whitish testaceous, the head, chitinized plates on dorsum, and the apical segment fuscous brown.

Head posteriorly sinuous in outline above, 2 small, narrow, dark plates on the membrane posterior to the central concavity. Thoracic segments each with 2 chitinized dorsal plates; prothoracic annuli each with 2 hairs on each side just in front of the outer half of the plates, these hairs being duplicated in the second annulus, each pair consisting of 2 hairs on a single base; second and third thoracic segments with similar hairs on posterior annuli, the anterior annuli without them; respiratory organ of moderate size, protruded. Basal abdominal segment biannulate, each annulus with a very small dorsal plate; following segments triannulate, the size of the dorsal plates on the anterior segments small, increasing posteriorly until on the last annulus of seventh segment the plate covers one half of the dorsal area; posterior annuli of all segments with a pair of duplicated hairs on each side, the other segments without long hairs; lateral margins of each of the posterior annuli with 2–3 long hairs; apical abdominal segment long and tapering, the terminal appendages small and slender; ventral segments each with a pair of long hairs on each side of the posterior annuli, the discal hairs, especially on middle of annuli, much longer and stronger than on dorsum, their apices bifid or trifid.

*Pupa*.—Length, 2.5–3.5. Prothoracic respiratory organ very similar to that of *minuta*, the openings of tracheae paired to base; apices of hind tarsi projecting very slightly beyond apices of wings. Armature of abdominal segments similar to that of *superba* but distinctly weaker, especially on apex of second dorsal segment, where the spinules are not well defined; apical segment with both the upper and lower pairs of apical thorns rather strong, the armature as in Figure 3, Plate XXXIX.

The foregoing descriptions are drawn from larvae and pupae which I obtained from a water trough in the dark room of the laboratory here in June, 1916. The pupal stage lasts from 3 to 5 days. The trough is not properly leveled, and along one side a small amount of water periodically accumulates which because of its unfiltered condition is soon permeated with an algal growth, in which the larvae feed.

Haseman's figure of the larva of *domestica* does not show the plates on the second abdominal segment. His description indicates that he found some variation in the number of plates on the basal 3 segments. My material does not show any variation.

Muttkowski's figure of the larva of *cinerea* does not show the dorsal hairs, but probably he overlooked these.

#### PSYCHODA ALBIMACULATA Welch

*Psychoda albimaculata* Welch, Ann. Ent. Soc. Amer., Vol. 5, 1912, p. 411.

Full descriptions of the larva, pupa, and imago are given by Welch in the paper above cited.

I have before me the same stages, obtained in the reservoirs at the 35th street pumping-station in Chicago. Welch's material came from the same reservoirs.

#### PSYCHODA sp. ?

Larvae of a species closely allied to *domestica* were obtained from a wound in a mulberry-tree, from which sap was exuding, at Urbana in July, 1915. My material is not plentiful enough to permit a definite decision regarding the specific identity of the species. A figure of the larva is given herewith (Pl. XXXIX, Fig. 14).

References to descriptions of immature stages of other North American species are given in the following list of notes and papers, the species dealt with being placed in parentheses in each case.

## PAPERS DEALING WITH BIOLOGY OF PSYCHODIDAE

Dell, J. A.

'05. Structure and life history of *Psychoda sexpunctata* [*alternata*]. Trans. Ent. Soc. London, 1905: 293-311.

Eaton, A. E.

'95. Supplementary notes on Dr. Fritz Müller's paper on a new form of larva of Psychodidae (Diptera) from Brazil. Trans. Ent. Soc. London, 1895: 489-493.

Fullaway, D. T.

'07. Immature stages of a psychodid fly. Ent. News, 18: 386-389. (*Psychoda schizura*.)

Haseman, L.

'07. A monograph of the North American Psychodidae, including ten new species and an aquatic psychodid from Florida. Trans. Amer. Ent. Soc., 33: 299-333. (*Psychoda floridica*.)'08. Notes on the Psychodidae. Ent. News, 19: 274-285. (*Psychoda domestica* and *P. nocturnala*.)'10. The structure and metamorphosis of the alimentary canal of the larva of *Psychoda alternata* Say. Ann. Ent. Soc. Amer., 3: 277-308.

Johnson, J. W. H.

'14. A contribution to the biology of sewage disposal. Jour. Econom. Biol., 9: 105-124, 127-164.

Kellogg, V. L.

'01. An aquatic psychodid. Ent. News, 12: 46-50. [*Pericoma (Maurina) californiensis*.]

Knab, F.

'13. New moth-flies (Psychodidae) bred from Bromeliaceae and other plants. Proc. U. S. Nat. Mus., 46: 103-106.

Miall, L. C., and Walker, N.

'95. The life history of *Pericoma canescens*.\* Trans. Ent. Soc. London, 1895: 141-147.

Müller, F.

'95. Contribution towards the history of a new form of larvae of Psychodidae (Diptera) from Brazil. Trans. Ent. Soc. London, 1895: 479-482.

Muttkowski, R. A.

'15. New insect life histories. Bull. Wis. Nat. Hist. Soc., 13 (No. 2): 109.

\*Deals with a European species, but listed because referred to in this paper.

Osten Sacken, C. R.

'95. Remarks on the homologies and differences between the first stages of *Pericoma* Hal., and those of the new Brazilian species. Trans. Ent. Soc. London, 1895: 483-489.

Welch, P. S.

'12. Observations on the life history of a new species of *Psychoda*. Ann. Ent. Soc. Amer., 5: 411-418. (*Psychoda albimaculata*.)

In addition to the foregoing, there are a number of excellent papers by Haliday, Koch, Zuelzer, Jacobfeurborn, and others, dealing with the larvae and pupae of European species.

### Family BLEPHAROCERIDAE

#### FAMILY CHARACTERS

*Larva*.—Head, thorax, and first and second abdominal segments fused; a slight transverse depression between the anterior margin of first abdominal and the posterior margin of the metathorax; a stout thorn on each lateral margin of one of the fused abdominal segments (second?) as on the other abdominal segments. Dorsal sclerites of head well defined; antenna well developed, slender, with 3 well-differentiated joints; mandibles opposed, strong; maxillary palpi rudimentary. Abdominal segments with very deep lateral constrictions between them, the protruded median portion of segments 3 to 7 each with 1 or 2 stout horns; apical segment rounded, without a horn or with a shorter one than those of the other segments. Sometimes the dorsum has a number of stout thorn-like protuberances in addition to those on lateral margins. Venter with a median longitudinal series of disc-like suckers, usually 6 in number, one on the thoracic complex, and one on each of the succeeding abdominal segments. Laterad of these suckers is a group of filaments which resemble the protruded ventral blood-gills of some species of *Chironomus* and may perform the same function.

*Pupa*.—Slug-like, ventrally unchitinized and flattened, so that it adheres closely to the rock bottom of the stream, dorsally convex and chitinized, the segments of abdomen distinct, but no noticeable constriction between base of abdomen and apex of thorax, the outline unbroken, oval. Thoracic respiratory organs lamellate, distinctly elevated. Legs extending nearly to apex of abdomen.

*Imago*.—Tipulid-like, body and legs very long and slender, wings large, with many reticulate creases between the veins, the effect produced being that of a secondary venation.

## HABITS OF LARVAE

The larvae of all species are aquatic, living in swift-running streams, and particularly in those that have rocky bottoms—to which they attach themselves by means of the suckers on the ventral surface of their bodies.

The food consists of diatoms, algae, and other small aquatic organisms.

## HABITS OF IMAGINES

The imagines are never found except in the vicinity of streams suitable for their larvae. The females are predaceous, feeding upon small insects such as chironomid midges; the males are recorded as feeding on nectar.

Owing to the fact that the larvae require very rapidly flowing pure water as their habitat no species are likely to be found except in mountainous regions, and it is improbable that any occur in Illinois.

## BIBIOCEPHALA sp. ?

*Larva* (Pl. XL, Fig. 1).—Length, 9–10 mm. Pale brown on dorsum, yellowish white on venter; head and chitinized dorsal thorns black.

Antennae elongate, constricted portions of joints whitish, the remainder black; entire dorsum of head chitinized, black; mouth-parts pale. Thoracic segments without thorns; a black triangular chitinized area on dorsum proximad of the first abdominal armature. Last segment of complex and all the abdominal segments except the apical with 4 stout horn-like protuberances on middle of dorsum, a much longer one near each lateral margin, and a pair of them on lateral margin, the upper one, with a shoulder at its middle, directed outward and armed at apex with 2 long hairs, the lower one directed slightly downward; apical segment with a pair of protuberances on dorsum and a number of long hairs on margin of apex of venter. Ventral suckers of moderate size. Lateral ventral blood-gills 5 in number in each group; apical blood-gills stout, 4 in number.

*Pupa* (Pl. XL, Figs. 2, 4).—Length, 6.5–8 mm. Dark brown.

Thoracic respiratory organs consisting of the usual 4 upright plates (Fig. 6), the length of the outer one being about  $1\frac{1}{2}$  times as great as its greatest width. Dorsal surface covered with minute, slightly raised dots; each abdominal segment with a group of larger blackish dots on each side about midway from median line to lateral margin, and between this group and the lateral margin a slight eleva-

tion. Ventral aspect as in Figure 2, the apices of legs not in a straight transverse line. In another specimen—which may be another species or the other sex of the present one—the legs terminate in an almost straight line.

Described from specimens collected in Jenny Creek, Tolland, Col., July 12, 1916 (B. Green).

The larva of this species differs from any other described from North America in the armature of the dorsum. In some species of *Bibiocephala* the larvae have indications of chitinized points, or warts, on the dorsum, but in none are they so well developed as in the present species, the nearest approach being an unnamed Colorado species figured by Kellogg in his revision of the group, Figures 11 and 12 of his paper ('00b).

Prof. T. D. A. Cockerell informs me that the only species recorded from the region where Miss Green obtained the larvae and pupae of the above species is *Bibiocephala grandis* Osten Sacken. It is not improbable that the larvae belong to this species, but on the evidence at hand I do not feel justified in suggesting that they do.

#### PRINCIPAL PAPERS ON NORTH AMERICAN BLEPHAROCERIDAE

Kellogg, V. L.

- '00. Notes on the life-history and structure of *Blepharocera capitata* Loew. Ent. News, 11: 305-318.
- '00a. A new blepharocerid. Psyche, 9: 39.
- '00b. The net-winged midges (Blepharoceridae) of North America. Proc. Calif. Acad. Sci., ser. 3, Zool., 3: 187-232.
- '07. Blepharoceridae. Gen. Ins., Fase. 56.

Riley, C. V.

- '81. Note on Blepharoceridae. Am. Nat., 15: 438-447.

#### Family CULICIDAE

No family of Diptera has received so much attention within the past twenty-five years as the Culicidae. This is due entirely to the fact that they are of very great economic importance, since in addition to their being in most cases a great annoyance to man because of their bloodsucking habits several species are directly instrumental in the transmission of various fevers, and other diseases, prevalent in the warmer parts of the world—such as malaria, yellow fever, and filariasis. The literature on the family is remarkably copious, and as it is generally accessible in America it is not the purpose of the writer

to give an extended review of the species here, the principal divisions being indicated only. Students who may desire a fuller knowledge of the family characters should consult the papers listed herewith.

I have retained Dixidae as a distinct family, contrary to the opinion of some writers who consider that the group should be ranked as a subfamily of Culicidae.

#### FAMILY CHARACTERS

*Larva*.—Head large, complete, exposed; mandibles moving horizontally; antennae well developed; mouth-brushes present (Culicinae) or absent (Corethrinae, pt.). Thoracic segments fused, appearing as a complex mass. Respiration carried on by means of posterior spiracles which open on last segment, their tips frequently in the form of elongated tubes, by means of which the larvae obtain a direct connection with the air by piercing the surface film of the water in which they live. In some of the Corethrinae there are present in the thorax and in the apex of the abdomen a pair of air-sacs which are usually black and conspicuous, contrasting with the glassy appearance of the larval body. These species do not keep a connection with the air, and are frequently found at great depths in lakes. Body with more or less conspicuous hairs or hair tufts.

*Pupa*.—As in the larvae, the thorax is conspicuously swollen; the respiratory organs are placed well back on the sides of the disc of the thorax—a characteristic that distinguishes the family from the Chironomidae. The abdomen has conspicuous hairs, some of those on the dorsum being stellate, and its apex is usually armed with 2 or 4 large, flat, paddle-like organs.

*Imago*.—Readily distinguished by the tomentose or scaled wings, slender build, long legs, complete marginal wing-vein; and by the absence of ocelli, of discal cell of wing, and of the v-shaped dorsal thoracic suture.

#### HABITS OF LARVAE

The larvae are aquatic, living under a variety of conditions, some of them in very deep water in lakes, some in shallow permanent pools, others in ditches that offer a permanent breeding-place or in water in depressions or receptacles that are of a temporary nature. The food of the species differs considerably, some of them being almost entirely vegetarian in habit, feeding on decaying detritus in the water or upon algae, while others are predaceous, feeding upon insect larvae and other small animals.

## HABITS OF IMAGINES

The female imagines of the Culicinae are almost entirely blood-suckers though some are found also upon flowers. Some species are the only known vectors of certain diseases, such as malaria, yellow fever, and filariasis. On account of this latter fact a very voluminous literature has appeared within the last twenty years, a brief list of some of the more recent and important works being given at the end of this summary of the family.

## KEYS TO SUBFAMILIES

## LARVAE

1. Apex of abdomen with a long respiratory tube.....2
- Apex of abdomen without elongate respiratory tube.....3
2. Antennae pendulous, hanging down in front of head and armed with 4 long and strong apical bristles (Pl. XLI, Fig. 1), or when at rest folded back against sides of head and armed with 2 or 3 strong apical claws.....CORETHRINAE, pt.
- Antennae porrect, not pendulous nor folded back against sides of head when at rest, and usually with a few weak bristles and one or two pointed processes (Pl. XL, Fig. 3).....CULICINAE, pt.
3. Anal segment cylindrical; last segment with a flat dorsal area in which are 2 spiracles; thorax and abdomen without black air-sacs.....CULICINAE, pt.
- Anal segment either bladder-like or the last segment with no spiracles and the larva transparent, glass-like; a pair of black air-sacs in thorax and another in seventh abdominal segment (Pl. XLI, Fig. 2).....CORETHRINAE, pt.

## PUPAE

1. Apical abdominal appendages acutely pointed.....CORETHRINAE, pt.
- Apical abdominal appendages rounded.....2
2. Thoracic respiratory organs elongate-oval, pointed at apex, black, contrasting sharply with color of thorax.....CORETHRINAE, pt.
- Thoracic respiratory organs more or less trumpet-shaped, never elongate-oval or pointed at apex, generally but little darker than thorax (Pl. XL, Fig. 8).....CULICINAE.

## IMAGINES

1. Proboscis short, not adapted for piercing.....CORETHRINAE.
- Proboscis very long, adapted for piercing.....CULICINAE.

## SOME OF THE MORE IMPORTANT WORKS ON NORTH AMERICAN CULICIDAE

Felt, E. P., and Young, D. B.

'94. The mosquitoes or Culicidae of New York State. Bull. 79, N. Y. State Mus.

Howard, L. O.

'00. Notes on the mosquitoes of the United States. U. S. Dept. Agr., Bur. Ent., Bull. 25, n. ser.

'10. Preventive and remedial work against mosquitoes. U. S. Dept. Agr., Bur. Ent., Bull. 88.

Howard, L. O., Dyar, H. G., and Knab, F.

'12. The Mosquitoes of North and Central America and the West Indies. (In 4 volumes, one of which is yet to appear.)

Johannsen, O. A.

'03. Aquatic Nematocerous Diptera. Bull. 68, Pt. 6, N. Y. State Mus., pp. 388-429. (Part of a comprehensive report, by various authors, on the aquatic insects of New York State.)

Family *DIXIDAE*

This is a small family, containing but one genus and about a score of described species. Some authors have considered them as forming a subfamily of *Tipulidae*, while others have placed them in the *Culicidae*. I am of the opinion that they are entitled to family rank, and so treat them in the present paper.

## FAMILY CHARACTERS

*Larva* (Pl. XL, Fig. 5).—Head complete, not retractile, antennae and maxillary palpi long and slender, mandibles opposed, stout; maxillae with a fringed lobe homologous with that of *Simuliidae* (Pl. XLI, Fig. 5); labium chitinized, densely hairy (Pl. XLI, Fig. 3). Thoracic segments distinct, similar in form to those of abdomen, the first 2 armed on anterior margin of dorsum with several long hairs. First and second abdominal segments each with a pair of pseudopods on dorsum, the apices of which are armed with curved spines; dorsum of segments 5, 6, and 7 each with a transverse pair of slight elevations which are armed with closely placed spines, or the segments with a transverse band of spines posteriorly; ventral surface of some of the abdominal segments usually with flattened areas which are armed on their margins with spines; preapical segment with a pair, or more, of long hairs; apical segment terminating above in a chitin-

ized tube-like process, which is armed with a number of long hairs, and ending below in a pair of slightly pointed processes which are fringed with closely placed hairs.

*Pupa* (Pl. XL, Fig. 7).—Antennae extending to or beyond middle of wings; palpi forming a semicircle, their apices incurved in front of clypeus; eyes rather small. Thoracic respiratory organs elevated, funnel-shaped; legs recurved against base of abdomen. Abdomen with 3 rather distinct sharp ridges on each segment, the apices of which are slightly serrate; apical segment terminating in 2 long, pointed processes; apical half of abdomen directed cephalad because of the curvature of the body, thus closely resembling the pupae of Culicidae.

*Imago*.—See key to imagines of Nematocera.

#### HABITS OF LARVAE

The larvae are aquatic, living in shallow wells, and in clear water such as is found in springs and slow-flowing mountain streams. The food consists of algae.

#### HABITS OF IMAGINES

The imagines occur in the vicinity of streams and may be swept from grasses or other vegetation overhanging the water. I have found them very commonly among grasses on almost perpendicular rocks that were continuously wet owing to water dripping over their surface. They have poorly developed mouth-parts, but I have found them on flowers, evidently feeding on nectar.

I have before me examples of the larvae and pupae, some of which were obtained by Mr. Hart at Havana, Ill., and others by Dr. S. A. Forbes in Yellowstone National Park. They differ from the species described by Johannsen in the armature of the abdomen and the structure of the apical segment, and in a few other particulars.

#### PAPER CONTAINING ACCOUNT OF NORTH AMERICAN DIXIDAE

Johannsen, O. A.

'03. Aquatic Nematocerous Diptera. Bull. 68, Pt. 6, N. Y. State Mus., pp. 429-432.

#### Superfamily *Chironomoidea*

This superfamily contains 3 families, Chironomidae, Ceratopogonidae, and Orphnephilidae.

The position of the last-named family has been somewhat in dispute amongst taxonomists, but the larval and pupal characters undoubtedly ally it more closely with Chironomidae than with any other family.

#### SUPERFAMILY CHARACTERS

*Larva*.—Head complete; antennae elongate, except in some Ceratopogonidae, retractile in Tanyinae; labial plate flat, usually notched anteriorly. Thorax and abdomen with distinct segments, 12 in number; pseudopods present upon prothorax and apical abdominal segments, on prothorax only, or entirely absent; respiration carried on by means of lateral prothoracic, abdominal, and anal spiracles, or by apical spiracles and anal blood-gills, or by the latter alone. Sometimes the anal blood-gills are permanently exserted and located on the latero-ventral margins of the apical segment, but usually they are entirely or partly retractile, or they are situated at apex of last segment and are somewhat leaf-like and not retractile.

*Pupa*.—Head without chitinized protuberances; antennae curved over eyes. Thoracic respiratory organs elevated, usually in the form of a single tube, and not uncommonly filamented, rarely sessile. Legs in Chironomidae recurved against base of venter of abdomen and apex of thorax; in the other families straight and not at all, or but slightly, exceeding length of wings. Abdomen in Chironomidae and Orphnophilidae with or without weak dorsal setulae, in Ceratopogonidae with leaf-like or thorn-like bristles; apical segment in Chironomidae usually with 2 or 4 pointed thorn-like protuberances.

*Imago*.—Antennae consisting of 6 to 15 joints; palpi 2- to 5-jointed, pendulous; proboscis in Chironomidae and Orphnophilidae poorly developed, in Ceratopogonidae well developed and chitinized. For synoptic characters see key to imagines on a previous page.

#### Family CERATOPOGONIDAE

After a careful examination of all the stages of this group and a comparison of these with the various stages of other families of the suborder I have decided to separate it, as a family, from Chironomidae, in which it has been previously placed as a subfamily.

#### FAMILY CHARACTERS

*Larva*.—Head complete (Pl. XLI, Fig. 15); mandibles (Pl. XLI, Figs. 13, 14) opposed, toothed or simple and hook-like; labium dis-

tinct; antennae small (Pl. XLI, Fig. 11). Respiration carried on by means of posterior spiracles or apical abdominal protrusive blood-gills; in the terrestrial forms I am unable to find lateral abdominal spiracles. Abdomen in aquatic forms worm-like, without pseudopods (Pl. XLII, Fig. 6), the only hairs present confined to apex of last segment; abdomen in terrestrial and semiaquatic forms with numerous bristles (Pl. XLII, Figs. 1, 2, 3, 4), the truly terrestrial species with distinct prothoracic and anal pseudopods, and some of the bristles on body leaf-like or lanceolate (Pl. XLI, Figs. 6, 7, 8, 9, 10).

*Pupa* (Pl. XLII, Fig. 5).—Head without thorns. Thorax compact, the wings and legs fused together and to thorax; apices of legs not, or but slightly, exceeding apices of wings, not recurved; thoracic respiratory organs elongate; disc of thorax in terrestrial forms with a number of long bristles. Abdomen with bristles or leaf-like protuberances; apical segment terminating in 2 or 4 thorns.

*Imago*.—Antennae in both sexes consisting of 15 joints, the apical 3, 4, or 5 usually noticeably longer than the others; male antennae plumose, that of female short-haired; mouth parts chitinized, fitted for piercing. Thorax not much arched, not overhanging head. Wings short; venation similar to that of *Chironomus*. Legs stout, the fore and mid pairs shorter than the hind pairs.

#### HABITS OF LARVAE

The larvae of *Forcipomyia* are terrestrial, feeding on cow dung, under bark of trees, and in decaying vegetation, and rarely they are found under decaying drift on the margins of rivers. The larvae of *Ceratopogon* occur on decaying wood in water, usually on submerged logs; those of *Culicoides* are also aquatic, occurring in tree-holes and in streams; while a species of *Pseudoculicoides* is found in exuding tree-sap. All species of other genera known to me are truly aquatic.

#### HABITS OF IMAGINES

The species of *Culicoides* are the well-known "punkies" and are invariably bloodsuckers. *Pseudoculicoides* is also a blood-sucking genus. I have no record of this habit for any of the other genera in so far as man and domestic animals are concerned, but they attack insects, attaching themselves to the body and wings.

## KEYS TO GENERA

## LARVAE

1. Pseudopods present on prothorax and apical abdominal segment..2
- Pseudopods absent, body worm-like (Pl. XLII, Fig. 6).....  
..... *Pseudoculicoides*, *Culicoides*, *Palpomyia*, etc.
2. Body circular in cross-section, armed with long bristles, some of which are leaf-like (Pl. XLII, Figs. 1, 2, 3).....*Forcipomyia*.
- Body flattened, oval in cross-section, armed with short simple bristles (Pl. XLII, Fig. 4).....*Ceratopogon*.

## PUPAE

1. Thorax without long bristles.....2
- Thorax with long bristles.....3
2. Thorax with short, pointed protuberances.....*Culicoides*.
- Thorax without distinct protuberances, at most with slight elevations (Pl. XLII, Fig. 5).....*Palpomyia*, etc.
3. Second abdominal segment with 4 bristles.....*Ceratopogon*.
- Second abdominal segment with about 10 bristles.....*Forcipomyia*.

## IMAGINES

1. Wings with distinct hairs on disc, either in the form of short upright microscopic setulae or broad decumbent scales.....2
- Wings without hairs on disc, rarely with a few near apex of costal margin.....6
2. Thorax with a distinct slit-like or circular depression on each side of disc slightly caudad of the inner angle of prothorax.....  
..... *Culicoides*.
- Thorax without these depressions.....3
3. Wings densely hairy, decumbent scale-like hairs present on whole surface.....4
- Wings with upright hairs which are usually absent on anal angle, no scale-like hairs present.....5
4. Basal joint of hind tarsi shorter than, or at most as long as, second.....*Forcipomyia*.
- Basal joint of hind tarsi very much longer than second.....*Euforcipomyia*.
5. Empodia absent; first and third veins of wings fused; tarsal claws of female very unequal in length.....*Neoceratopogon*.
- Empodia present; first and third veins of wings connected by a cross-vein; tarsal claws of female equal.....*Ceratopogon*.
6. First and third vein connected by a cross-vein or fused basally.....7
- First and third veins disconnected for their entire length.....11
7. At least one pair of femora with distinct ventral spines.....8

— Femora without ventral spines.....	10
8. Generally more than one pair of femora with spines; neither fore nor hind femora noticeably thickened.....	<i>Palpomyia</i> .
— Only fore or hind femora with spines, the spinose pair perceptibly thickened.....	9
9. Fore femora thickened and spinose.....	<i>Heteromyia</i> .
— Hind femora much thickened and spinose.....	<i>Scromyia</i> .
10. Media sessile.....	<i>Johannsenomyia</i> .
— Media petiolate.....	<i>Hartomyia</i> .
11. At least one pair of femora with ventral spines.....	12
— Femora not spinose.....	13
12. Media sessile.....	<i>Bezzia</i> .
— Media petiolate.....	<i>Pseudobezzia</i> .
13. Media sessile.....	<i>Probezzia</i> .
— Media petiolate.....	<i>Parabezzia</i> .

N. B. The genus *Atrichopogon* is distinguished by the bare wings and distinct empodia. I have no species belonging to this genus.

When I wrote my paper on the Chironomidae of Illinois, in which I included the present family as a subfamily of Chironomidae, I had obtained data upon and materials representing the early stages of but one species of *Culicoides*. In 1916 I succeeded in obtaining a pupa of another species in the Sangamon River, and the larvae and pupae of one from water which had collected in a hollow tree-stump in the forestry of the University of Illinois, at Urbana. These discoveries prove that the genus is truly aquatic, as stated in my previous paper, and ought to dispel the doubts of the fact that have been expressed by some dipterologists. I was also successful in obtaining the larvae and pupae of a species of *Pseudoculicoides* from a wound on the trunk of an elm tree on the university campus. The sap was flowing freely from the wound, and associated with this species were many larvae of *Mycetobia divergens*, which superficially resemble those of *Pseudoculicoides*. The larvae of *Culicoides* and *Pseudoculicoides* are very similar to those of *Palpomyia*. The characters distinguishing them will be dealt with in a future paper—provided I can command the time necessary for the study.

#### Family CHIRONOMIDAE

In this paper I have included in this family only two subfamilies, Tanypinae and Chironominae.

## FAMILY CHARACTERS

*Larva*.—Head complete; mandibles opposed, toothed; antennae elongate; labial plate dentate anteriorly. Thoracic segments distinct, rarely slightly swollen in Tanypinae; prothoracic pseudopods present, usually fused to or nearly to apex, and of moderate length, rarely very short, always armed at apices with hairs or bristles. Abdomen consisting of 8–9 segments; apical segment in aquatic species with a dorsal pair of papillae, upon which are several long hairs, and usually 2 or 4 small non-retractile blood-gills caudad of these and between the bases of the posterior pseudopods, the apical claws of the latter normally retractile, ventral blood-gills sometimes present; apical segment in terrestrial forms without dorsal papillae, with small pseudopods, the blood-gills small and wholly or partly retractile; larvae peripneustic, at least with minute lateral abdominal spiracles which may not function, or metapneustic, respiration being carried on by means of the anal papillae and blood-gills; body without strong hairs or bristles, sometimes with numerous soft hairs.

*Pupa*.—Antennae elongate, curved over upper margin of eyes; head without spines, occasionally with a pair of conical tubercles at base of antennae. Thoracic respiratory organs usually elongate, rarely sessile, located near anterior margin of thorax; wings extending slightly beyond base of abdomen; legs elongate but recurved against venter so that they project but little if any beyond apices of wings. Abdomen circular or oval in cross-section, either without long hairs or prominent bristles or the former confined to the lateral margins and strap-like, and the bristles small and located on disc of segments or at their apices; apical segment with 2 more or less flattened, fin-shaped appendages.

*Imago*.—A great majority of the species resemble mosquitoes in their general build. The costa is, however, not continued round the entire wing; there are no scale-like hairs on the wings; and the mouth-parts are not constructed for piercing, being usually poorly developed.

## HABITS OF LARVAE

By far the greater number of the species are aquatic in the larval and pupal stages, only a few of the more specialized species in Chironominae being terrestrial. The food of the aquatic forms consists of algae, decaying vegetable matter, diatoms, and small Crustacea. The terrestrial forms known to me occur in manure and decaying vegetable matter.

## HABITS OF IMAGINES

The imagines are found in great numbers in the vicinity of lakes, ponds, rivers, or other bodies of water. They are particularly numerous at lights at night. Many of the species do not appear to feed in this stage, but some are found on flowers, evidently partaking of the nectar or feeding on the pollen, and I have seen one species feed upon moist fly-specks on a store-window at night.

For a further discussion of the habits of this family see my paper on the Illinois species listed at the end of this summary.

## KEYS TO SUBFAMILIES

## LARVAE

1. Antennae retractile; labium with 4 to 7 teeth, reversible internally; thoraeic segments usually more or less dilated. .... *TANYPINAE*.
- Antennae not retractile; labium usually with more than 7 teeth, not reversible; abdominal thoraeic segments not dilated. .... *CHIRONOMINAE*.

## PUPAE

1. Thorax much distended, the head much below upper level thereof; thoraeic respiratory organs simple, egg- or cornucopia-shaped; abdominal segments without strong dorsal spinules; apieal processes flat, sometimes rounded at apiees and with a few strap-like hairs on margins. .... *TANYPINAE*.
- Thorax not much distended, the head not much below the upper level thereof; thoraeic respiratory organs branched, often with many thread-like filaments, or if simple the abdomen has usually dorsal spinules and the apieal segment has the pair of processes pointed. .... *CHIRONOMINAE*.

## IMAGINES

1. Medio-cubital cross-vein present; wings frequently hairy; antennae in both sexes with 15 joints; male hypopygium with each side consisting of a short basal piece and an apical slender process which is usually curved and acute at tip. .... *TANYPINAE*.
- Medio-cubital cross-vein absent, or if present the antenna of the female has only 8 joints and the hypopygium of the male has in addition to the 2 pieces present in *Tanypinae* another piecee projecting along the inner side of the basal portion which bears a fringe of long hairs; antenna of male 15-jointed, occasionally with fewer joints, that of female 8-jointed. .... *CHIRONOMINAE*.

## Subfamily TANYPINAE

## SUBFAMILY CHARACTERS

*Larva* (Pl. XLIII, Fig. 1).—Head usually much more elongate than in Chironominae (Pl. XLIII, Figs. 7,8); antennae long and slender, retractile; palpi longer than their diameter; labial plate hinged, retractile by turning upon its base, the anterior margin being thus frequently found directed inward and backward in preserved specimens, form of plate spatulate, armed with 4 to 7 teeth. Thoracic segments more or less swollen and differentiated from the abdominals; prothoracic pseudopods well developed. Abdomen slender, often armed with soft hairs which it is very difficult to see; anal pseudopods sometimes very long; dorsal papillae distinct, armed with a number of long hairs; apical blood-gills 4 in number.

*Pupa* (Pl. XLIII, Fig. 3).—Thorax much more distinctly swollen than in Chironominae, the respiratory organs always simple, not conspicuously fringed, frequently egg-shaped (Fig. 10) or trumpet-shaped. Legs and wings rather short, the former recurved against venter. Abdomen without noticeable dorsal armature; lateral margins with a few long strap-like hairs; apical appendages flattened, their margins with several long strap-like hairs, and sometimes with a short fringe.

*Imago*.—See key to subfamilies.

## Subfamily CHIRONOMINAE

This subfamily contains many more genera than does Tanyptinae, and among them are some of the commonest of the Nematocera.

## SUBFAMILY CHARACTERS

*Larva*.—Readily distinguished from larvae of Tanyptinae by their stout, non-retractile antennae and the flat, exposed, fixed labial plate. The blood-red color of some of the larvae of *Chironomus* has earned for them the popular name of "blood-worms".

*Pupa*.—The pupae of all species of *Chironomus* known to me have the thoracic respiratory organs divided into many thread-like filaments, and are separated by this character from every other nematocerous family. The species that have these organs pedunculate more nearly resemble the pupae of Tanyptinae, but the latter are generally more culicid-like, having the thorax more swollen and the abdomen

curved forward ventrally, while the Chironominae are almost invariably straight.

*Imago*.—See key to subfamilies.

#### KEYS TO GENERA

##### LARVAE\*

1. Two or four permanently exserted blood-gills present on the penultimate abdominal segment (Pl. XLIII, Fig. 5) .. *Chironomus*, pt.
- No permanently exserted blood-gills present on penultimate abdominal segment..... 2
2. Prothoracic pseudopods poorly developed (Pl. XLI, Fig. 17); anal pseudopods fused, in the form of a single sessile disc whose margins are furnished with small hooks (Pl. XLI, Fig. 12); anal dorsal papillae absent; terrestrial species (Pl. XLI, Fig. 16)..... *Camptocladius*.
- Prothoracic and anal pseudopods well developed, not sessile; anal dorsal papillae usually present and furnished with several apical hairs..... 3
3. Abdominal segments each with a distinct pencil of hairs on each side..... *Cricotopus*, pt.
- Abdominal segments without pencil of hairs on either side..... 4
4. Labium consisting of a pale rounded central piece and a digitate, dark, heavily chitinized piece on each side..... *Chironomus*, pt.
- Labium not as above, the lateral margins continuous, and not in the form of separate digitate plates..... 5
5. Color of living larva blood-red; antennae short, not half as long as head, maxillary palpi long..... *Chironomus*, pt.
- Color of living larva green or yellowish, rarely faintly reddish..... 6
6. Larva living within a case one end of which has a number of slender tentacular protuberances (Pl. XLIII, Fig. 9)..... *Tanytarsus*.
- Larva free, or if enclosed the case is not as above but more in the form of a rough tunnel-way, and there are no protuberances on either end..... 7
7. Dorsal papillae on apical segment much longer than their diameter..... *Metriocnemus*.
- Dorsal papillae on apical segment about as long as their diameter. 8
8. Antennae much more than half as long as head..... 9
- Antennae not more than half as long as head..... 10
9. Very small species, not more than 2.5 mm. in length; only 2 permanently exserted blood-gills at apex of abdomen..... *Corynoneura*.
- Larger species, usually more than 5 mm. in length; 4 permanently exserted blood-gills at apex of abdomen..... *Tanytarsus*.

\*Specific identifications may be reached by using the keys to larvae and pupae in my paper on this family listed at the end of this portion of the present paper.

10. Maxillary palpi usually noticeably longer than their diameter; anterior margin of labium transverse or slightly convex, the sides not sloping abruptly away from the central portion (Pl. XLIII, Fig. 4) ..... 11

— Maxillary palpi usually about as long as their diameter; anterior margin of labium usually centrally transverse, the sides sloping abruptly backward from the central portion (Pl. XLIII, Fig. 2).  
..... { *Orthocladius*, pt.  
..... { *Cricotopus*.

11. All labial teeth rounded or all acute ..... *Chironomus*, pt.

— Central labial tooth rounded, broader than laterals, which are very acute ..... *Diamesa*.

## PUPAE

1. Thoracic respiratory organs consisting of numerous long hair-like filaments..... *Chironomus*.
- Thoracic respiratory organs stalk-like, sometimes furnished with a few surface filaments; or sessile..... 2
2. Abdominal segments in part with paired spot-like groups of conspicuous black spinules which are visible to the naked eye..... *Tanytarsus*.
- Abdominal segments without distinct spot-like groups of black spinules, the surface either bare or with much less conspicuous armature which is distributed over a large area of each segment and is only visible under a strong lens..... 3
3. Thoracic respiratory organs sessile..... 4
- Thoracic respiratory organs stalk-like..... 7
4. Abdominal segments without stout teeth on their posterior margins, and otherwise unarmed..... *Camptocladius*.
- Abdominal segments, except basal and apieal, with stout teeth on their posterior margins, or with setae on dorsum..... 5
5. Setulae confined to disc of segments, no postmarginal teeth or spines present..... *Thalassomyia*.
- Short teeth or spines present on posterior margins of some of the abdominal segments..... 6
6. Disc of dorsal segments with a band of distinct setulae; apical appendages without long hairs..... *Metriocnemus*, pt.
- Disc of dorsal segments without a band of distinct setulae; apical appendages each with 3 long hairs..... *Dianesia*.
7. Abdominal segments, except basal and apieal, each with a conspicuous postmarginal series of strong spinules..... 8
- Abdominal segments, except second, without a conspicuous postmarginal series of strong spinules..... { *Orthocladius*, pt. *Cricotopus*.

8. Apical abdominal appendages each with 3 long terminal hairs.....  
 ..... *Metriocnemus*, pt.  
 — Apical abdominal appendages each with 2 short and inconspicuous hairs before apices.....  
 ..... *Orthocladius*, pt.

IMPORTANT PAPERS ON NORTH AMERICAN CHIRONOMOIDEA\*

Johannsen, O. A.

'05. Aquatic Nematocerous Diptera. II. Bull. N. Y. State Mus., No. 86: 76-315. (This paper contains descriptions of all species of Tanypiniae and Chironominae that had appeared in North America up to the time of its publication, and a very full bibliography of the superfamily Chironomoidea.)  
 '08. New North American Chironomidae. Bull. N. Y. State Mus., No. 124: 264-285. (Contains a few keys to genera and species supplementary to those of the previous paper, and also a small additional bibliography.)

Malloch, J. R.

'15. The Chironomidae or midges of Illinois, with particular reference to the species occurring in the Illinois River. Bull. Ill. State Lab. Nat. Hist., Art. VI, 10: 275-543. (Contains keys to genera and recognizably described species of North American Ceratopogonidae, and keys to larvae and pupae of some Chironomoidea.)  
 '15. Some additional records of Chironomidae for Illinois and notes on other Illinois Diptera. Bull. Ill. State Lab. Nat. Hist., Art. IV, 11: 305-363. (Contains descriptions of some genera and species not included in the previous paper, and notes on habits.)

Family *ORPHNEPHILIDAE*

I have not seen the larva or pupa of this family. There are but two genera in the family, *Orphnephila*, containing three species, and *Androprosopa*, with two. Only one species of *Orphnephila* is recorded as occurring in North America, the other genus being entirely unrepresented here as far as we know at present. The following generalizations for larval and pupal stages are taken from Thienemann's descriptions of the immature stages of *Orphnephila testacea* Ruthé, a European species occurring in the United States.

Because of my failure to obtain the early stages of this family I have not included it in my keys to the larvae and pupae of Nematocera.

\*As previous authors have included in Chironomidae all the families I have now put in Chironomoidea I have listed papers dealing ostensibly with the Chironomidae under the superfamily, in accordance with the arrangement of the present paper.

## FAMILY CHARACTERS

*Larva*.—General appearance as in Chironominae, the prothoracic and anal pseudopods, anal dorsal papillae, and paired apical dorsal blood-gills being as in that subfamily. Details of the structure of the head are lacking in Thienemann's description, but his figure shows that the shape of the head more closely resembles that of *Forcipomyia* than that of *Chironomus*, the mouth opening ventred instead of on the anterior face. The prothoracic spiracles resemble small warts. The thoracic and abdominal segments are longer than broad, clearly differentiated, and armed with numerous spinules. The prothoracic and anal pseudopods are armed at the apices with curved spines as in Chironomidae.

*Pupa*.—The pupa is distinguished from pupae of Chironomidae by the stout, short thoracic respiratory organs, which are covered with minute warts, by the presence of small warts on almost the entire body surface, and by the structure of the apical segment, which has at the tip 2 rather long, slender, upwardly directed processes and 2 long slender hairs.

*Imago*.—See key to imagines of Nematocera.

## HABITS OF LARVAE

The larvae are found in swift-flowing streams, and have the same food habits as those of Chironomidae.

## HABITS OF IMAGINES

The imagines are very sluggish in habit and are rarely taken on the wing. Nearly all the specimens that I have taken in Britain, where *Orphnephila testacea* occurs commonly, were swept from grasses and ferns on the overhanging banks of mountain streams. This species occurs very rarely in this country.

## Tribe OLIGONEURA

I have included in this tribe the superfamilies Cecidomyioidea and Bibionoidea, while Brauer included only the former. The arrangement may not be an ideal one, and probably some may consider the superfamilies as belonging to separate tribes; but to my mind they have many characters that link them together, though not so closely as is the case with the families in Polyneura. If, however, they must be separated, I would associate neither of the groups with any

other tribe, but Bibionoidea should constitute a new tribe and Cecidomyioidea remain as the only superfamily in Oligoneura.

#### CHARACTERS OF THE TRIBE

*Larva*.—In some respects the larvae of Cecidomyioidea are very primitive; in fact, if we consider their respiratory system—which is almost without exception functionally peripneustic—and the number of segments (13) as of primary importance we must place these insects with the most generalized of the Diptera. But, probably owing to the mode of life of the larvae, the head has undergone considerable transformation, until, with the absence or vestigial nature of the mandibles and the almost invariable reduction of the head-capsule posteriorly, we have what is undoubtedly a much specialized form. The much reduced heads of these larvae separate them readily from other Nematocera.

The Bibionoidea differ from the foregoing in having the head-capsule complete and the mandibles developed; and in that all the species known in the larval stage have lateral abdominal spiracles—some functional and others not. The species of *Bibio* known to me have apparently 13 segments in addition to the head, and 8 pairs of lateral spiracles in addition to the prothoracic and anal pairs—characters which indicate that they are very primitive. The aquatic forms (Simuliidae) have peculiarly modified mouth-parts, and because of their living in running water show adaptations in other respects. The Bibionidae and Scatopsidae are terrestrial, and while the lateral abdominal spiracles are present, I believe that in some cases they are doubtfully functional.

*Pupa*.—The pupae of both superfamilies are structurally primitive. The head in the species of Cecidomyiidae that live in galls is armed with sharp chitinized thorns by means of which the pupa bores its way to the surface prior to the emergence of the imago. The other members of the tribe possess no cephalic thorns. The thoracic respiratory organs are sessile in most species, being elongated only in Scatopsidae, Simuliidae, and a few Cecidomyiidae. For other characters see synoptic keys and descriptions of families.

*Imago*.—See synoptic key to the imagines of Nematocera.

#### Superfamily *Cecidomyioidea*

But one family is referable to this superfamily. It is of considerable extent, world-wide distribution, and of much economic importance.

Family *CECIDOMYIIDAE*

I have not devoted much time to rearing this family, and my material is limited, consisting of a few species that were picked up in the course of other work, those that form the existing collection of this Laboratory, and a number that were kindly supplied by Dr. E. P. Felt. Judging from my examination of this material, there appear to be quite a number of good distinguishing characters for both larvae and pupae. Owing to the very large number of species included in the family it would require a great amount of work and the expenditure of much time to devise a satisfactory classification of the early stages. I have figured a few details of some of the larvae and pupae as indices of the general character of these stages. Kieffer, in "Genera Insectorum"\*, has given, in addition to generic synopses of imagines, a summary of the larval and pupal characters of the family, and keys to the known larvae of the European genera. These keys will no doubt prove serviceable to students of the North American species.

Dr. E. P. Felt has been for several years studying this family, and his work on the imagines has done more to clear up this obscure group than that of any other worker either in America or abroad.

## CHARACTERS OF THE FAMILY

*Larva*.—The head is not so heavily chitinized as in other families of the Nematocera, and on that account, and because it is generally incomplete posteriorly and very small, it is rather difficult to distinguish details, especially in the small species; the eyes and mandibles are apparently absent, but the antennae are long and 2- or 3-jointed. The presence of 13 segments, exclusive of the head and of lateral abdominal spiracles, is sufficient to distinguish the larvae of this family from any other in the order except Bibionidae, and here the complete head of the latter serves to distinguish the two families. Normally there is present also, at least in the mature larvae, a chitinized plate under the membrane on the ventral surface of the second thoracic segment. This plate differs considerably in the different species, and its form is of value for identification purposes. It serves the larvae as a means of propulsion in making their leaps after leaving their pabulum to pupate, or when they are removed therefrom and placed upon a dry surface. Many species form galls upon plants, and may be identified by these alone, as each species usually attacks but

\*Fasc. 152. (1913)

one plant species, or a few closely allied plants, and the resultant gall is characteristic of the insect. Certain species that live in resin of trees have the lateral abdominal spiracles vestigial and the apical pair very much enlarged.

*Pupa*.—It is not a simple matter to indicate characters by means of which the pupae of this family may be distinguished from those of allied families because there are within its limits species that differ greatly in their larval habits, some living in hard, woody galls, and others in decaying fungi, manure, mines in leaves, or under bark, the nature of the material in which the pupa is found having a considerable influence upon the structure of the head. I have found it true in other groups that when the species have in the pupal stage to force their way through either hard earth, wood, or the enclosing cocoons of some host, the head-capsule of the pupae is armed with a number of sharp thorns well suited to the purpose of boring a way out so that the imago may be able to emerge. On the other hand, species that either do not penetrate deep into soil or wood, that are aquatic, or normally frequent moist ground, do not have cephalic thorns. From my limited data this rule appears to hold good in the Cecidomyiidae, the species that must bore their way out of galls having the head armed with sharp thorns, while those that are found in fungi, manure, or decaying wood have no such armature. According to my present data, the presence of cephalic thorns may be depended upon to separate the species possessing them from other Neamatocera, no other family of which has such thorns, but the species without such thorns are difficult to separate from those of Sciaridae. The comparative sizes of the first and second tarsal joints of Cecidomyiidae serve to separate the pupae of most of this family from those of Sciaridae, the basal one being much shorter than the second in the former while in the latter it is distinctly longer.

*Imago*.—The antennae differ considerably in the number of their segments, ranging from 16 to 30 in different genera, and not infrequently differing in the sexes of the same species. Usually the antennal segmentation is very distinct, the segments being often nodose, or even binodose, and armed with whorls of long hairs. In Cecidomyiinae looped hairs which have no free end are present on the antennae, being undoubtedly sense organs. The legs are usually long and slender, and in some groups the basal joint of the tarsi is very much shorter than the second. The wings are characterized by the small number of the longitudinal veins, and the absence of cross-veins except near base; the surface is usually pubescent or covered with depressed, scale-like hairs.

Kieffer bases separation of the larvae of Cecidomyiinae from those of Lestremiinae and Heteropezinae on the situation of the anal opening, which in the former is on the ventral surface of the apical segment, while in the other two subfamilies it is situated at the extremity of that segment. No character for the separation of Lestremiinae and Heteropezinae is given in his subfamily key, nor are there any tangible distinctions mentioned in his discussion of the larvae of these subfamilies. No attempt has been made, to my knowledge, by any writer to designate characters for the separation of the pupae of the different subfamilies.

#### RETINODIPLOYSIS PINI-INOPS Osten Sacken

*Cecidomyia pini-inops* Osten Sacken, Stett. Ent. Zeit., 1861, p. 418.

*Retinodiplosis pini-inops* (Osten Sacken) Kieffer, Gen. Ins., Fase. 152, p. 221. (1913)

*Larva*.—(Pl. XLIV, Fig. 1). Length 8 mm. White (alcoholic specimens), head and spiracles black.

Head consisting of a chitinized frame with enclosed membranous areas (Pl. XLIV, Fig. 6); antennae slender, 2-jointed, rather small. Thoracic segments with a transverse series of short black hairs near anterior margin on dorsum, the ventral surface of each segment with several small rounded elevations; prothoracic spiracles larger than the abdominal pairs. Spatula present but not as heavily chitinized as in most allied genera (Fig. 12). Dorsum of first seven abdominal segments each with a transverse pair of pseudopod-like processes the apices of which are bifid, each branch with a slender black bristle; a bifid process similar to processes of dorsum, but shorter, situated just ventrad of each spiracle; venter with 2 transverse series of short, rounded elevations; apical segment not elongated, spiracles (Fig. 9) larger than lateral pairs of other segments, situated on upper posterior margin and rather widely separated.

*Pupa*.—Unknown to me.

The foregoing description was made from specimens sent me by Dr. E. P. Felt, which were obtained in New York State, April 25, 1916. The larva does not agree with the characters cited for the larva of *Retinodiplosis* by Kieffer in the paper cited under the species heading here, but without material representing the other species for comparison I can not venture an opinion as to the exact generic status of *pini-inops*. The structure of the head agrees closely with that of *Cecidomyia resinicoloides*.

## MONARDIA sp.?

*Larva*.—Length, 3-4 mm. Body cylindrical, the segments clearly defined. Head (Pl. XLIV, Fig. 3) more fully developed than in the preceding species, the antennae much stouter. Spatula tridentate, heavily chitinized; prothoracic spiracles larger than abdominal pairs. Abdominal spiracles small, present on the basal 7 segments; apical pair small, not elevated; locomotor spinules minute, in numerous transverse series on anterior portion of all ventral abdominal segments.

*Pupa* (Pl. XLIV, Fig. 7).—Length, 2 mm.

Head with 2 long hairs between bases of antennae and one hair on each eye; palpi curved along posterior margin of eye. Thorax with 4 long hairs. Legs longer than wings, the hind pair reaching beyond middle of fourth abdominal segment and distinctly beyond apices of mid pair, the latter slightly longer than fore pair. Abdomen without armature; spiracles indistinguishable.

Described from specimens submitted by Dr. E. P. Felt, from New York State.

## RHABDOPHAGA PODAGRAE Felt?

*Rhabdophaga podagrae* Felt, Bull. 124 N. Y. State Mus., p. 355. (1908)

A large number of specimens that appear to belong to this species were reared here from slightly swollen willow twigs by members of the office staff some years ago. The pupal exuvia differ from those of the following species, reared from *Bidens frondosa*, in having only 2 strong thorns on head (Pl. XLIV, Fig. 8)—lacking those on middle and lower margin of face. The thoracic respiratory organs are sessile. The abdomen has no stiff spinules on the dorsum, and the apices of the fore tarsi do not extend beyond apices of wings (Pl. XLIV, Fig. 2).

## RHABDOPHAGA sp.?

A number of specimens of a species which probably belongs to this genus were reared from *Bidens frondosa* some years ago. The pupal exuvia present the following characters.

*Pupa*.—Head with a pair of very strong acutely pointed thorns at base of antennae (Pl. XLIV, Fig. 5), a much smaller pair below these, on center of face, which are curved upward and fused nearly to apices, and 3 small upwardly directed spines, on a common base, on lower portion of face (Pl. XLIV, Fig. 4). Thoracic respiratory organs bristle-like, elevated and very slender; dorsum of thorax glos-

sy; legs extending much beyond apices of wings, the apices of fore and mid tarsi ending at apex of fourth segment, those of hind pair extending slightly beyond that point. Dorsum of all abdominal segments except first with stout short spines arranged in 2 transverse bands, the anterior one consisting of 3-4 series of spines, the posterior of one series; apical segment almost globose; spiracles distinct.

IMPORTANT PAPERS ON NORTH AMERICAN CECIDOMYIIDAE

Ekel, L. S.

'03. The resin-gnat *Diplosis* and three of its parasites. Ent. News, 14: 279-284.

Felt, E. P.

'06-'16. Reports of the State Entomologist of New York. (These reports include a vast amount of information upon this family, and contain by far the best articles on it that have appeared here or in Europe.)

Osten Saeken, C. R.

'62. Monographs of North American Diptera. Part I, pp. 179-198.

'69. Biological notes on Diptera. Art. I. Trans. Am. Ent. Soc., 2: 299-303.

'71. Biological notes on Diptera. Art. II and III. Trans. Am. Ent. Soc., 3: 51-54, 345-347.

Williams, F. X.

'09. The Monterey pine resin midge—*Cecidomyia resinicoloides*, n. sp. Ent. News, 20: 1-8.

'10. The anatomy of the larva of *Cecidomyia resinicoloides* Williams. Ann. Ent. Soc. Amer., 3: 45-57.

Superfamily *Bibionoidea*

I have restricted Coquillett's superfamily Bibionoidea to include only Simuliidae, Bibionidae, and Scatopsidae.

The imagines present closer affinities than do the larvae at a first glance, but characters that link the larvae are not wanting. It is very evident throughout all orders that a difference in larval habitat, and especially the difference between an aquatic and a terrestrial one, results in a very marked difference in the structure of the larva. It is possible that I have placed too much emphasis upon the structure of the imagines and overestimated the effect of different habitats upon larval structure in my grouping of the families placed here. I believe, however, that these families are closely related, in fact more closely related to each other than any one of them is to any other family in

Nematocera, and for this reason I have placed them in this superfamily.

#### SUPERFAMILY CHARACTERS

*Larva*.—Head complete; mandibles opposed; antennae well developed. Abdomen with lateral abdominal spiracles, functionless in Simuliidae and possibly so in Scatopsidae; prothoracic and anal spiracles large in Bibionidae and Scatopsidae, the anal pair separated and more or less elevated; abdomen in Simuliidae with apical protrusive blood-gills.

The larvae of Simuliidae superficially resemble those of some Chironomidae, but may be separated by the long mouth-brushes, which consist of many slender branches upon a common base, opening and closing fanwise. Somewhat similar mouth-brushes are found in some related, and also in some quite unrelated, forms, and are evidently independently developed to meet the requirements of a particular mode of life.

*Pupa*.—The pupae of all the families are short and stout, and those that I have examined present a wide diversity of characters. In Simuliidae we find the pupae partly enclosed in cocoons, the structure of which varies somewhat with the species, and in the pupae of all species of the family the respiratory organs consist of a number of slender filaments attached to a common base on each side of thorax anteriorly. The abdomen is armed with short spines in transverse series, which aid in retaining a hold upon the surface of the cocoon. Scatopsidae, or at least the species known to me, differ in having the pupa free, the thoracic respiratory organs furcate, and the abdomen without spines, but with the spiracles elevated. Bibionidae have neither elevated thoracic respiratory organs nor abdominal spines, and show a more primitive structure throughout. The pupae of all the families have the legs straight—a character which readily separates them from the pupae of the chironomid and culicid groups.

*Imago*.—Antennae 8- to 12-jointed; eyes of male sometimes contiguous above and with the facets of the upper half much larger than those of the lower; eyes of female separated; ocelli present or absent; proboscis short, in part chitinized in Simuliidae. Wings large, the veins of the anterior portion much stronger than those of the posterior; posterior cross-vein never present.

#### Family BIBIONIDAE

The larvae which I have examined differ from those of every other family I have seen in three particulars: the false segment behind

the head is fully developed and armed with spinose processes; the prothoracic spiracle is apparently on the second segment; and metathoracic spiracles are present. For an idea of the general appearance of the larva, see Figure 10, Plate XLIV.

The larva of *Plecia* as figured by de Meijere agrees in all essential details with that of *Bibio*\*.

The characters of the larva indicate that it is structurally very primitive, and in comparison with the adult it is apparent that in this family larval specialization has not gone forward as fast as has the specialization of the imago, the advancement of the latter being evidenced by the reduction of the number of antennal joints and wing veins. In the Tipulidae the reverse is true, larval specialization being farther along than that of the imago, and distinctly in advance of that of the larva of Bibionidae.

The presence of the pseudosegment and the additional pair of spiracles on the last thoracic segment readily separate Bibionidae from Scatopsidae.

#### FAMILY CHARACTERS

*Larva* (Pl. XLIV, Fig. 10).—Head complete; mandibles opposed; antennae pedunculate. Body apparently 13-segmented, and with pointed fleshy processes; pseudopods absent; a pair of spiracles on prothorax (second apparent segment), another on metathorax, and one pair on each of the following seven segments; anal spiracles very large, sessile, situated near anterior margin of segment.

*Pupa* (Pl. XLIV, Fig. 11).—Antennae rather short, curved, lying across upper half of eyes; palpi directed laterad. Thoracic respiratory organs very slightly elevated; legs short, tarsi of fore pair lying over those of mid pair and not extending to their apices, the apices of mid pair extending to apices of wings, apices of hind pair extending slightly beyond apices of wings; wings extending nearly to apex of second segment of abdomen, overlying and hiding all but apices of hind tarsi. Abdomen without spines or bristles.

#### HABITS OF LARVAE

The larvae, as far as known, are scavengers, feeding in the earth upon decaying roots or other portions of dead plants, and are very often found in large numbers closely congregated under fallen logs and, occasionally, under horse dung and cow dung. The species are very

\*Tijd. v. Ent., Vol. 53, pp. 59-63; Pl. IV, Fig. 1. (1910)

difficult to rear, and very few reared specimens are before me although several species are not uncommon in this vicinity.

I have reared one hymenopterous parasite from a breeding-cage containing larvae of this family, but doubt its connection with *Bibio* as its host.

#### HABITS OF IMAGINES

The imagines of *Bibio femoratus* fly in April in this latitude and are sometimes very common. The name "March-fly", applied to adults of the family by some writers, does not justify the natural interpretation of the term, as they do not appear in this country until later in the year than March. The term is probably due to a misinterpretation of the significance of the specific name of a European species of *Bibio*, *B. marci*, supposed to owe its name to its occurrence on the wing about St. Mark's Day (April 25). Popular names are very frequently misleading, and no encouragement should be given to the currency of any which may be derived from the characteristics of a single species, which can never properly serve as a criterion by which to judge of the remainder of the family.

The species that occur early in the season are instrumental in pollinating blossoms of various fruit-trees, upon which they occur very commonly. They fly readily even on dull days, and on this account are more generally serviceable as pollinators than bees, which are seldom active except during sunshine.

#### IMPORTANT PAPERS ON BIOLOGY OF NORTH AMERICAN SPECIES

Lintner, J. A.

'85. Second Annual Report of the State Entomologist of New York, pp. 110-115. (Gives description of imago of *Bibio albipennis* and notes on life history.)

Needham, J. G.

'02. A remarkable occurrence of the fly *Bibio fraternus* Loew. Am. Nat., 36: 181. (Gives figures of larva and pupa.)

#### Family SCATOPSIDAE

Until recently the species of this family have been included in the family Bibionidae, but all stages of the species herein dealt with present good characters for their separation from that family.

## FAMILY CHARACTERS

*Larva*.—Head complete; mandibles opposed, antennae elongate. Larva peripneustic, having prothoracic and elevated lateral abdominal and apical abdominal spiracles, the latter situated upon 2 widely separated stalk-like protuberances. Body with slender hairs.

*Pupa*.—Head without thorns; antennae curved over upper portion of eyes. Thoracic respiratory organs pedunculate, in the species before me furcate. Wings short; apices of hind legs barely extending beyond apices of wings. Abdomen unarmed; spiracles elevated, stalk-like.

*Imago*.—Separable from Bibionidae by the wing venation. (See key to imagines of Nematocera.)

## HABITS OF LARVAE

The larvae of this family are scavengers, feeding in manure and on decaying vegetation. I have also found them under loose bark of fallen trees.

## HABITS OF IMAGINES

The flies are found on flowers, manure, decaying fruit, and very frequently on windows.

## RHEGMOCLEMA ATRATA Say

*Seatopse atrata* Say, Appendix to Keating's Narrative of an Expedition to the Source of St. Peter's River, p. 367. (1824)

*Seatopse fuscipes* Meigen, Syst. Beschr. Eur. Zweifl. Ins., Vol. 6, p. 314. (1830)

*Seatopse recurva* Loew, Linnaea Ent., Vol. 1, p. 330. (1846)

*Rhegmoclema atrata* (Say) Melander, Bull. 130, Wash. Agr. Exper. Station, p. 12. (1916)

*Larva* (Pl. XLV, Fig. 1).—Length, 3-4 mm. Yellowish gray; head brownish yellow; surface hairs on body pale brown; spiracular protuberances blackish; apical respiratory processes brownish yellow; apical processes caudad of the latter black.

Antennae longer than in *Bibio* (Pl. XLV, Fig. 8). Pseudosegment indistinguishable; prothoracic spiracles more distinctly elevated than the abdominal pairs; metathorax without spiracles. Entire body covered with rather short slender hairs. Apical segment with 4 processes on dorsum—a pair near base which are stouter than the pre-apical pair and bear the spiracles, and a much more slender pair near apex which are crowned with several short hairs. Abdominal spiracles slightly elevated.

*Pupa* (Pl. XLV, Fig. 2).—Length, 2.5–3.5 mm. Darker than the larva.

Head declivitous anteriorly (Pl. XLV, Fig. 3); antennae much longer than in *Bibio*, extending to bases of wings (Fig. 4); palpi directed slightly cephalad. Thoracic respiratory organs (Fig. 5) furcate, as long as width of thorax; fore tarsi overlying mid femora, ending much proximad of apices of mid pair, the latter ending at apices of wings and very slightly proximad of apices of hind pair (Fig. 4). Basal segment of abdomen shorter than second and without an elevated spiracle (Fig. 3), the next 6 segments with stalk-like spiracles; entire body without hairs or bristles.

The foregoing descriptions were made from examples obtained from cattle cars on the railroad siding at White Heath, Ill., June 24, 1916. These cars had not been cleaned, and there was about four inches of straw and manure in the bottom of each, in which were thousands of larvae of *Rhagiomoclema*, *Sciara*, *Muscidae*, *Borborus*, *Leptocera*, and *Coleoptera*. Such cars serve to disseminate manure-frequenting species, and should not be allowed to stand for a week or two uncleaned on sidings, as in this case.

I have also reared *R. atrata* from rotten plums.

#### PAPER ON NORTH AMERICAN SCATOPSIDAE

Melander, A. L.

'16. The dipterous family Scatopsidae. Bull. 30, Wash. Agr. Exper. Station, Div. Ent. and Zool. (1916)

#### Family SIMULIIDAE

This family is of very small extent, consisting of but three genera. The species are not very numerous, but some of them occur in vast numbers in certain parts of this country and in Europe. The common names black-flies, sand-flies, and buffalo-gnats have been applied to them in this country.

In 1914 I published a revision of the North American species which will be found useful to any student of the group who intends making identifications of our native species. This and other papers on the Simuliidae are listed at the end of this summary of the family.

#### FAMILY CHARACTERS

*Larva* (Pl. XLVI, Fig. 1).—Head complete; maxillae very large, armed with very large mouth-brushes; labium dentate; thorax with

a pair of closely fused pseudopods; thoracic segments slightly swollen; apical 3-4 segments of abdomen much swollen, giving the larva a slightly club-shaped appearance; apical segment with a sucker-like disc which is armed with a number of stout, short, hook-like bristles arranged in concentric series.

*Pupa* (Pl. XLV, Fig. 9; Pl. XLVI, Figs. 2, 3).—Head without projecting spines; palpi directed caudad; thoracic respiratory organs each consisting of 4 to 60 tube-like filaments; legs extending but little beyond apices of wings; abdomen armed with short spines on apices of segments. The pupae are enclosed in a slipper-shaped or pocket-like cocoon (Pl. XLVI, Fig. 4) or occasionally in a tangled mass of loose threads.

*Imago*.—Antennae 11-jointed, the joints of the flagellum short and rather closely attached. Eyes of male confluent, with the facets of the upper half much larger than those of the lower half (Pl. XLVI, Fig. 5); eyes of female rather widely separated, the facets of nearly uniform size throughout. Wings without cross-veins in the disc; radius with 2 or 3 branches. Abdomen with 7-8 segments, and a flap-like scale at base the apex of which is fringed with long soft hairs. Legs stout; metatarsus very long and stout; claws trifid in male, bifid or simple in female.

#### HABITS OF LARVAE

The known larvae of the species of this family are aquatic, invariably living in water that is in motion, never occurring in ponds or stagnant water. Removal to still water in vials or other vessels results in the death of the specimens in a few hours. The food of the larvae consists of diatoms, algae, and other minute organisms. When disturbed in the streams in which they occur the larvae usually release their hold upon the surface of the rock, or other object in the bed of the stream, and float off to some distance, maintaining slight attachment, however, by means of a silken thread which emanates from the mouth. When the danger has passed they regain their former hold in the bed of the stream by means of this thread. Their method of locomotion reminds one forcibly of that of the geometrid moths, consisting of a series of looping movements, interrupted by frequent pauses during which the head and the anterior portion of the body are moved restlessly from side to side as if the insect were looking for something. Most species hibernate in the larval stage, appearing as imagines in spring and early summer. A few species have evidently more than one brood in the year.

The larvae are very commonly attacked by internal bacteria and other parasitic organisms, but are not, as far as I know, subject to attack by insect parasites.

#### HABITS OF IMAGINES

The species occur in the neighborhood of rivers and streams, and some are very persistent biters, attacking cattle, domestic fowls and animals, and even man. The bite is very painful, and cases are on record of the death of horses and mules as the result of their attacks. There are also a few records of the death of persons from the same cause. Within the past twenty years or so the species have evidently grown comparatively scarce in the Mississippi Valley, being now very seldom reported as injurious there. The building of levees along the rivers in the middle West, with the coincident reduction in flooding and the subsequent falling of the water which supplied the necessary breeding conditions for these insects, has contributed largely to the decrease in their numbers.

#### PRINCIPAL PAPERS ON NORTH AMERICAN SIMULIIDAE

Barnard, W. S.

'80. Notes on the development of a black fly (*Simulium*) common in the rapids around Ithaca, N. Y. Am. Ent., 3:191-193.

Forbes, S. A.

'12. Black-flies and Buffalo-gnats (*Simulium*) as possible carriers of pellagra in Illinois. 27th Rep. State Ent. Ill., pp. 21-55.

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*Addenda to Nematocera*

*Addendum 1*

When at work upon the portion of my paper dealing with Limnobiidae, I unfortunately overlooked some larvae whose family identity I had had doubts about, not returning to them as intended,

and in order to make this study as comprehensive as possible I give here a brief description of the species.

Subfamily TRICHOCERINAE

TRICHOCERA sp.?

*Larva*.—Length, 10 mm. Pale testaceous.

Head complete, similar to that of the Alaskan species described under the above subfamily name on a previous page of this paper. Prothoracic spiracle small, surrounded by a pale ring; anterior third of prothorax paler than posterior two thirds; each thoracic segment with a transverse linear depression at middle on dorsum, the venter without depression; first abdominal segment with a median transverse linear depression on dorsum and venter, the other segments, except the apical one, with 2 such depressions which divide the segments into 2 short anterior portions and a longer posterior one; apical segment different from that of the Alaskan species in having the ventral blood-gills distinct, in the form of an irregular protuberance (Pl. XLV, Fig. 6), and the 4 processes round the spiracular disc shorter and of almost uniform length (Fig. 7).

Described from specimens obtained by me at White Heath, Ill., March 12, 1916, where the larvae were common under leaves and debris that had collected in depressions and holes in tree-stumps several feet high in a wood along the bank of the Sangamon River. The eggs may have been deposited by late-flying adults after snow covered the ground, when the tree-stumps only were free from it, and this may account for the occurrence of the larvae in this elevated situation. I failed in my attempt to rear the species, and having provisionally placed it in Bibionidae I overlooked it till it was too late to include it in its proper place in this paper.

*Addendum 2*

The species described below is evidently a limnobiid, but I do not care to venture a suggestion as to its affinities. Though the head bears a resemblance to that of Pediciinae, the apical segment is quite different from that of the species of that family known to me.

GENUS INCERTUS

*Larva*.—Length, 10 mm.; diameter, 1 mm. Yellowish testaceous; head dark brown on the more heavily chitinized parts, remainder pale brown; anal respiratory disc dark brown.

Head retractile, narrow; dorsal slits very narrow, ventral one broad and extending so far forward that the labium is divided centrally; antennae very short and stout; labrum obtuse at apex; maxillae stout, palpi very robust, nearly as thick as the maxillae and slightly shorter; mandibles stout, slightly curved, their apices obtusely rounded, teeth short, rounded, 3 in number, all on a median protuberance; labium divided in center, the sides without distinct teeth. Body cylindrical, covered with dense decumbent pile, segments longer than broad, with the usual transverse incised lines present in Limnobiidae; apical segment shorter than preapical, its posterior surface obliquely truncate, heavily chitinized, the spiracles small and widely separated, situated near upper extremity of the round plate; ventral blood-gills absent.

Described from a specimen in the collection of this Laboratory which was taken in a cabbage field at Rose Hill, Cook Co., Ill., September 26, 1883.

The round heavily chitinized apical plate is very similar to that of *Coenomyia*.

### Division BRACHYCERA

There is a diversity of opinion among systematists regarding the arrangement of the families of this division, and while the general scheme in the present paper is essentially the same as that proposed by Brauer it differs in some respects from that of any previously published classification. The two tribes, *Platygenya* and *Orthogenya*, are those used by Brauer, but I have discarded his group names *Homeodactyla* and *Heterodactyla*, retaining the superfamily divisions which he indicated, but using names derived from one of the included families in order to conform to the rules governing nomenclature. Both of Brauer's discarded groups—which have a status between his tribe and superfamily—are heterogeneous, and while the present arrangement may not be ideal, it appears to me a better and less cumbersome one than Brauer's.

The classification adopted by Verrall differs in many respects from that of Brauer, and is based entirely on imaginal characters. I can not accept Verrall's linking together of *Scenopinidae* and *Mydaidae* in one superfamily in view of the close resemblance between the larvae of the former with those of *Therevidae*, and consider that they really belong to the same superfamily as *Therevidae* despite some resemblances the imagines bear to those of *Mydaidae*.

It is unnecessary to go into details regarding the various classifications proposed. A resumé of them may be found in Williston's Man-

ual of North American Diptera (1909) and in Verrall's British Flies, volume 5 (1909).

TABULAR ARRANGEMENT OF FAMILIES

<i>Tribes*</i>	<i>Superfamilies</i>	<i>Families†</i>
Platygenya	Stratiomyioidea	{ Stratiomyiidae Xylophagidae Coenomyiidae Acanthomeridae
	Tabanoidea	{ Tabanidae Leptidae
	Cyrtoidae	{ Cyrtidae Nemestrinidae
	Asiloidea	{ Mydidae Apoiceridae Asilidae Bombyliidae
	Therevoidea	{ Therevidae Scenopinidae
Orthogenya	Empididoidea	{ Empididae Dolichopodidae

KEYS TO FAMILIES

LARVAE

- Posterior spiracles approximated, situated within a terminal or sub-terminal cleft or chamber, usually concealed; body entirely shagreened or wholly or in part longitudinally striated. .... 2
- Posterior spiracles rather widely separated, visible, situated on apical segment, which may be truncated, chitinized, or armed with

\*Tribe in this paper does not have the application given to it in contemporary papers, but has that which Brauer gave it. He used it to designate his subdivisions of the larger divisions of Nematocera and Brachycera.

†The sequence of the families in the keys is not in accordance with the above list, the keys being framed to facilitate identification and not to indicate affinities.

apical processes; or upon penultimate or antepenultimate segment; body not shagreened or visibly striated.....3

2. Head not retractile; body flattened, surface finely shagreened, sometimes with lateral abdominal spiracles, without vestigial pseudopods; spiracular fissure transverse, sometimes rather small; pupae enclosed in larval skin.....STRATIOMYIIDAE (p. 315).

— Head retractile; body cylindrical, surface not shagreened, usually longitudinally striated, abdomen with a girdle of pseudopods on each segment; spiracular fissure vertical; pupa free.....TABANIDAE (p. 355).

3. Posterior spiracles situated upon apical segment.....4

— Posterior spiracles situated upon penultimate or antepenultimate segment.....10

4. Projecting portion of head and flattened apical plate of terminal abdominal segment heavily chitinized: the former cone-shaped, entirely closed except at extreme apex, not retractile; the latter obliquely truncate and with projecting processes.....5

— Projecting portion of head more or less retractile, not cone-shaped, the movable portions not enclosed; apical abdominal segment without a heavily chitinized flattened terminal plate.....6

5. Head about twice as long as its greatest width; thoracic segments not chitinized above, each with 2 internal separated chitinized plates; body without long hairs; apical plate very large, spiracles vertically elongated, apical paired protuberances small, widely separated, each with a short hair on inner side.....COENOMYIIDAE (p. 351).

— Head at least 3 times as long as its greatest width; at least the first and second thoracic segments chitinized above, no internal chitinized plates present; body with a number of long hairs, 4 of which, in a vertical series on each abdominal segment, are very noticeable; apical plate rather small, spiracles rounded, apical paired protuberances large, fused basally, each with a number of rather long hairs.....XYLOPHAGIDAE (p. 346).

6. Posterior spiracles widely separated, located in an apical transverse cleft; head very small, retractile.....NEMESTRINIDAE (p. 368).

— Spiracles not located in an apical transverse cleft.....7

7. Apical abdominal segment ending in 2 long processes which are fringed with long soft hairs; abdomen with paired pseudopods and fleshy dorsal and lateral appendages..LEPTIDAE, pt. (p. 362).

— Apical abdominal segment not as above, paired abdominal pseudopods usually, other appendages always, absent.....8

8. Apical abdominal segment ending in 4 short pointed processes or 2 fleshy lips; internal portion of head with a large, arched, chitinized upper plate, the longitudinal rods and other cephalic parts on a horizontal plane.....LEPTIDAE, pt. (p. 362).

- Apical abdominal segment not as above, or the internal portion of head is without arched upper plate, and the longitudinal cephalic rods and other cephalic parts meet at right angles.....9
- 9. Apical abdominal segment without projecting processes, the spiracles very small; species internal parasites of spiders.....  
.....CYRTIDAE (p. 368).
- Apical abdominal segment frequently with projecting processes, the spiracles large; species living in water, mud, earth, or decaying vegetable matter..... { EMPIDIDAE.....(p. 400).  
{ DOLICHOPODIDAE (p. 403).
- 10. Posterior spiracles situated upon antepenultimate segment; abdominal segments 1-6 subdivided, the body apparently consisting of 20 segments exclusive of the head.....11
- Posterior spiracles situated upon penultimate segment; abdominal segments simple, the body apparently consisting of 11 or 12 segments exclusive of the head.....12
- 11. Posterior dorsal internal extension of head spatulate at apex; ventral posterior projections in the form of 2 short chitinized rods...  
.....THEREVIDAE (p. 396).
- Posterior dorsal internal extension of head not spatulate at apex; ventral posterior projections absent.....SCENOPINIDAE (p. 398).
- 12. Penultimate abdominal segment longer than ultimate, with a deep transverse depression near its apex giving it the appearance of 2 distinct segments; ultimate segment terminating in a sharp ridge with a median sharp point, on either side of which dorsally and ventrally are situated 4 very closely approximated hairs similar to those in Asilidae.....MYDAIDAE (p. 370).
- Penultimate abdominal segment shorter than ultimate, or if longer, then without a deep transverse depression; apical segment not as above, the hairs not closely approximated.....13
- 13. Thoracic segments each with 2 long hairs, one on each side on ventro-lateral margin; apical segment with 6 or 8 long hairs; head well developed, forwardly protruded, and more or less cone-shaped when viewed from above, appearing flattened when viewed from the side; penultimate segment usually shorter than ultimate or not much longer; body straight in life.....ASILIDAE (p. 373).
- Thoracic segments without hairs, or if these are present they are very weak; apical segment without distinguishable hairs; head not much protruded, directed downward, not cone-shaped, with a dorsal protuberance when viewed from the side; penultimate segment distinctly longer than ultimate; body usually curved in a half circle in life.....BOMBYLIIDAE (p. 389).

## PUPAE

- 1. Pupa enclosed within the last larval skin..STRATIOMYIDAE (p. 315).
- Pupa free.....2

2. Prothorax with a large aperture mesad of and connected with the spiraele.....TABANIDAE (p. 355).

— Prothorax without an aperture mesad of the spiracle.....3

3. Head without strong forwardly directed thorns, at most with one thorn on base of antenna which is directed laterad; abdominal armature weak, becoming gradually stronger towards apex of abdomen; wings short, extending to or very slightly beyond apex of basal abdominal segment; apices of hind tarsi at most extending slightly beyond apices of wings; abdomen with 7 pairs of spiraeles . . . . .4

— Head usually with strong thorns, or if these are absent the abdominal armature is stronger on basal or second segment than it is on apical or there are less than 7 pairs of abdominal spiraeles present; apices of hind tarsi usually extending distinctly beyond apices of wings.....6

4. Antennal sheaths much thickened at bases, apical portion slender, styliform, the whole directed almost straight downward.....LEPTIDAE (p. 362).

— Antennal sheaths thickened throughout their length, the apical portion generally more or less distinctly annulated, the whole directed either straight laterad or in a slightly downward direction..5

5. Antennal sheaths very stout, not over twice as long as their basal breadth; face with a small sharp protuberance on each side a little mesad of the vertical line of apices of antennae and slightly above middle of face, and at the base of each are 2 short hairs on their inner side; 2 very strong postspiracular abdominal bristles on each segment.....COENOMYIIDAE (p. 351).

— Antennal sheaths distinctly annulated, slender, about 4 times as long as their basal breadth; face without protuberance; postspiracular abdominal bristles slender, 8-10 on each segment.....XYLOPHAGIDAE (p. 346).

6. Head without strong thorns; abdomen with 3-4 distinct pairs of spiraeles and without spinose armature.....CYRTIDAE (p. 368).

— Head usually with strong thorns, at least with elevated ridge-like antennal sheath and several small carinated elevations; abdomen with 7 pairs of spiraeles and spinose armature.....7

7. Head with 2 thorns.....8

— Head with more than 2 thorns or with several short tubercles.....9

8. Abdomen with a single transverse series of spines on each dorsal segment; wing with a long thorn at base....THEREVIDAE (p. 396).

— Abdomen with 2 transverse series of spines on each dorsal segment; wing without thorn at base.....SCENOPINIDAE (p. 398).

9. Upper pair of cephalic thorns directed laterad and slightly upward; apices of wings extending to or very slightly beyond apex of first abdominal segment; apices of middle tarsi not extending to apices of wings.....MYDAIDAE (p. 370).

- Upper pair of cephalic thorns directed forward, at most slightly divergent apically, generally slightly curved downward or head without strong upper thorn.....10
- 10. Head with strong thorns, or if these are absent the abdomen has the dorsal transverse armature consisting of very strong thorns and intervening long slender hairs; apices of antennae obtuse.11
- Head very rarely with strong thorns, 2 carinate elevations present on upper anterior margin; antennae with apices attenuated; body without thorns, sometimes with bristles.....12
- 11. Lower median portion of face with a closely approximated pair of stout thorns which are occasionally fused almost to apices; abdomen with the transverse armature of the dorsal segments consisting of short flattened thorns and long slender hairs, the thorns usually appearing as if attached to rather than forming a part of the abdomen and sometimes turned up at bases and apices.....  
..... BOMBYLIIDAE (p. 389).
- Lower median portion of face without thorns; abdomen with the transverse armature consisting of alternating long and short thorns except in *Leptogaster*.....  
..... ASILIDAE (p. 373).
- 12. Cephalic armature consisting of 2 carinated elevations on upper anterior margin, on each of which is a very long hair; antennal sheaths raised above level of face, tapering apically, directed downward and slightly outward; proboscis much elongated.....  
..... EMPIDIDAE (p. 400).
- Similar to foregoing, but with the proboscis short.....  
..... DOLICHOPODIDAE (p. 403).

#### IMAGINES

- 1. Empodium pulvilliform, nearly or quite as large as the pulvilli, so that 3 rounded pads or scales appear under the tarsal claws....2
- Empodium either absent or in the form of a slender thread, with or without surface hairs, so that there are only 2 distinct pads or scales under the tarsal claws.....8
- 2. Third antennal joint distinctly annulated or the antenna consisting of more than 3 distinct joints.....3
- Antenna consisting of 3 joints, the third not annulated.....6
- 3. Costal vein discontinued at or close to the apex of wing.....  
..... { STRATIOMYIIDAE\* (p. 315).  
..... { ACANTHOMERIDAE (p. 354).
- Costal vein continued round apex of wing, sometimes encircling the whole posterior margin.....4
- 4. Squamae very large.....  
..... TABANIDAE (p. 355).
- Squamae small, sometimes vestigial.....5

\*The family Acanthomeridae is doubtfully distinct from Stratiomyidae. I have no species of the former, all occurring in South America.

5. Robust species, with spinose scutellum; marginal vein encircling wing. .... *COENOMYIIDAE* (p. 351).

— Slender species, with unspined scutellum; marginal vein ceasing before reaching anal angle of wing. .... *XYLOPHAGIDAE* (p. 346).

6. Squamae very large, inflated; robust flies, with very small heads. .... *CYRTIDAE* (p. 368).

— Squamae very small. .... 7

7. Costa continued round posterior margin of wing. .... *LEPTIDAE* (p. 362).

— Costa discontinued at apex of wing. .... *NEMESTRINIDAE* (p. 368).

8. Anal cell much longer than second basal, closed at or close to wing-margin, or open; third vein usually fuscate. .... 9

— Anal cell absent or, if present, shorter than second basal, or but little longer, and closed some distance from wing-margin; if the apex of this cell is long and pointed the third vein is not forked. .... 14

9. Vertex depressed, seen from in front the upper inner angles of eyes are considerably above the level of the frons; eyes always separated. .... 10

— Vertex not depressed, at least on a level with upper inner angles of eyes; eyes of male often contiguous. .... 11

10. Fourth vein curved forward apically, ending at or before tip of wing. .... *MYDAIDAE* (p. 370).

— Fourth vein not curved forward. .... *ASILIDAE* (p. 373).

11. Posterior cross-vein present, i. e., second basal cell with an obtuse apex formed by a cross vein; 5 posterior cells present. .... 12

— Posterior cross-vein absent, i. e., second basal cell with an acute apex; rarely 5 posterior cells present, if present the fifth cell is due to the bisection of the third by a cross vein. .... 13

12. Fourth vein curved forward and ending before the apex of wing. .... *APIOCERIDAE* (p. 373).

— Fourth vein not appreciably curved forward, ending behind apex of wing. .... *THEREVIDAE* (p. 396).

13. Fourth vein curved forward, ending at or before apex of wing; proboscis retracted, fleshy; antennae without apical style. .... *SCENOPINIDAE* (p. 398).

— Fourth vein ending behind apex of wing; proboscis slender, usually much exserted; antenna usually with a style. .... *BOMBYLIIDAE* (p. 389).

14. Discal cell usually separated from the second basal, always at least one distinct basal cell; squamae small; abdomen of male usually with 7 segments exclusive of the hypopygium; black, brownish, or yellowish species, usually with chitinized proboscis. .... *EMPIDIDAE* (p. 400).

— Discal cell not separated from second basal, the basal cells small and indistinct; squamae moderately large, usually with con-

spieuous fringe; abdomen of male usually with 5 or 6 segments in addition to the hypopygium; metallic greenish or bluish species, usually with fleshy proboscis... DOLICHOPODIDAE (p. 403).

### Tribe PLATYGENYA

The larvae of members of this tribe are distinguished from those of Orthogenya by the structure of the head, the plates forming it being flat and straight, when not enclosed within a conical chitinized capsule, and lying on a horizontal plane when at rest. Occasionally the exposed portion of the head is heavily chitinized on the anterior half, forming a cone from whose small apical opening the mandibulate processes protrude.

I am unable to give characters for the differentiation of the pupae of this tribe from those of Orthogenya, the species of the latter known to me being so few that a generalization based on them would probably prove misleading.

This tribe contains all of the Brachycera except Dolichopodidae and Empididae. Characters for the separation of these families will be found in the preceding key to different stages.

### Superfamily *Stratiomyioidea*

#### SUPERFAMILY CHARACTERS

The family Acanthomeridae is confined to tropical America and is unknown to me, but the other three families are represented in all stages in my material.

*Larva*.—Head with the anterior half cone-shaped, permanently exserted, in Xylophagidae and Cecidomyiidae heavily chitinized, the mandibulate processes protruded through a small opening in the apex. The larvae of Stratiomyiidae have the head less heavily chitinized than do those of the other two families known to me in that stage, but the anterior half is non-retractile—a character which separates these larvae from those of other superfamilies. Many of the genera have distinguishable spiracles on metathorax and abdomen which are probably not functional. For other distinguishing characters see key to laryae of Brachycera and descriptions under family headings.

*Pupa*.—The pupae of Stratiomyiidae are enclosed within the last larval skin—a fact which separates them from other Brachycera. The pupae of Xylophagidae and Coenomyiidae are free, and differ from those of other Brachycera known to me in having the antennae with well-defined annuli.

*Imago*.—See key to imagines of Brachycera.

Family *STRATIOMYIIDAE*

The larvae of this family are readily separated from those of any allied family by their characteristic general appearance (Pl. XLVII, Figs. 1, 2, 3), and the finely shagreened surface of the body. All the genera so far described have larvae that differ appreciably in the following details: head structure, chaetotaxy, indentation of lateral margins of abdominal segments, length and structure of the apical segment, and structure and armature of the anal respiratory chamber. In the aquatic forms the apical respiratory chamber, which contains the openings of the spiracles, is furnished along its margins with long plumose hairs. When the larva is close to the surface of the water the anal extremity is curved upward till the tips of the respiratory or spiracular chamber are free of the water, the radiating hairs then expanding upon the surface film and preventing the water from flooding the chamber and interfering with respiration. When the larva descends below the surface the hairs are drawn inward, enclosing a large air-bubble which is carried in this manner until nearly exhausted, when the larva again ascends to the surface. The terrestrial forms lack the plumose hairs bordering the anal respiratory chamber and the latter is in some genera located upon the disc of the segment some distance before the apex instead of at the extreme apex as in the aquatic forms.

No other species in Orthorrhapha known to me, except a few in Cecidomyiidae, transform to the pupal stage within the larval skin, and because of this peculiarity it will only be necessary to give a key to the larvae in the family. I have mainly used material in the Laboratory collection in drawing up the keys presented, but in a few cases I have also made use of published descriptions or borrowed material.

## CHARACTERS OF THE FAMILY

*Larvae and Puparia*.—Twelve-segmented exclusive of the head, the latter attached at middle to first thoracic segment, and usually with a distinct ocular prominence on each side at varying distances from front margin and numerous long hairs on dorsum and venter; antennae distinct; pseudopods absent, penultimate and antepenultimate segments sometimes armed with locomotor hooks on caudal margin of ventral surface; anterior spiracles near posterior margin of side of first segment; lateral metathoracic and abdominal spiracles present or absent; posterior spiracles separated, located in a transverse slit-like cavity which may be apical or preapical and fringed with long plumose hairs or unfringed; entire surface of body finely shagreened.

## HABITS OF LARVAE

The aquatic larvae feed upon algae, decaying vegetable matter, and small Crustacea. The terrestrial species occur in a variety of situations, some of them being found in nests of Hymenoptera, or in those of rodents—where they act as scavengers; others occurring under loose bark of living or recently felled trees, feeding upon the sap, or on dipterous larvae; while still others feed upon decaying vegetation or on manure. One genus (*Hermetia*) has been recorded as feeding upon the dead body of a man.

## HABITS OF IMAGINES

The species are most active on sunshiny days, some of them being much given to settling upon leaves of trees which are in full sunlight. Most species frequent flowers, especially those of Umbelliferae, feeding upon the nectar, and are particularly numerous on marshy ground or along the margins of streams, ponds, or other bodies of fresh water. Few species occur on the seashore and I know of none that that are found in the larval stage in salt water.

The eggs are usually laid in masses on the leaves of aquatic plants, as shown in Figure 4, Plate XLVII.

## KEY TO SUBFAMILIES

## LARVAE AND PUPARIA

1. Apical abdominal segment very much longer than broad and very distinctly tapered, but if the length is not over 3 times that of the basal width the antepenultimate and penultimate ventral segments have each 2 or 4 stout curved thorns on their posterior margins; posterior spiracular chamber at apex of last segment, the margin armed with numerous soft, plumose or pubescent hairs; aquatic species. .... *STRATIOMYIINAE* (p. 317).
- Apical abdominal segment not over twice as long as its basal width; if the species is aquatic and has the posterior spiracular chamber armed with marginal hairs the ventral thorns are absent. .... 2
2. Aquatic species; bristles on dorsum paired, very short, sometimes thickened apically; posterior spiracular chamber margined with long, soft, plumose or pubescent hairs. .... *CLITELLARIINAE*, pt. (p. 322).
- Terrestrial species; bristles on dorsum single, long and tapered, or in groups; posterior spiracular chamber on dorsum of apical segment, transverse, not margined with soft hairs. .... 3
3. Each segment with a deep notch in each lateral margin slightly before middle, dividing the segment into 2 unequal lateral lobes (Pl. XLIX, Fig. 11) .... *Genus incertus* 1 (p. 344).

- Segments without lateral notch.....4
- 4. Bristles on dorsum very short, arranged in groups of 3-4; lateral bristles arranged similarly, two such groups on each side of each segment.....BERIDINAE (p. 331).
- Bristles on dorsum and lateral margins long, not in groups.....5
- 5. Head much elongated, the portion anterior to eyes distinctly longer than its greatest width; antennae of moderate length, apical portion slender; the 6 conspicuous hairs on dorsal surface of thoracic and abdominal segments not in an almost straight transverse series, the median pair close to anterior margin and very much longer and stronger than the 2 lateral pairs, which are close to posterior margin; thorax and abdomen without long decumbent hairs.....*Genus incertus* 2 (p. 345).
- Head not much elongated, the portion anterior to eyes about as long as its greatest width; or if the head is elongated the hairs on abdomen are in straight or almost straight transverse series.....6
- 6. Very large robust species, over 18 mm. in length; antennae of moderate length, apical portion stout; eyes moderately prominent; head distinctly narrowed immediately behind eyes, almost parallel-sided; thoracic and abdominal segments densely covered with decumbent lanceolate hairs.....CLITELLARIINAE, pt.
- Smaller species, 10-12 mm. in length at most; antennae very small; eyes very prominent.....7
- 7. Thoracic segments 1 and 2 each with a smooth plate on dorsum; apical segment with a transverse series of short teeth near base on ventral surface which are directed caudad.....XYLOMYIINAE (p. 340).
- Thoracic segments without smooth plate on dorsum.....8
- 8. Bristles slightly clubbed with the exception of some of those on head and those on apical segment.....*Genus incertus* 3 (p. 345).
- Bristles tapered to a point, not clubbed.....9
- 9. Robust species; dorsum distinctly striate; head short and broad.....GEOSARGINAE (p. 331).
- Slender species; dorsum unicolorous, brown or testaceous; head long and slender.....PACHYGASTERINAE (p. 334).

### Subfamily STRATIOMYIINAE

#### SUBFAMILY CHARACTERS

*Larva and Puparium*.—Head elongate, armed as in Figures 1 and 2, Plate XLVIII; antennae well developed; maxillae very elaborate, the palpi well developed; mandibles weakly chitinized, the teeth slender. Body with rather weak armature, sometimes with scale-like hairs on dorsum, and in *Odontomyia* with strong thorns (2 or 4) on posterior margin of penultimate, or of both penultimate and ante-

penultimate, ventral segments; lateral abdominal spiracles indistinguishable; apical segment much elongated; the apical 3 or 4 segments tapered posteriorly in *Stratiomyia*; posterior spiracular chamber in apex of last segment, fringed with long soft hairs.

*Imago*.—Third antennal joint without a differentiated arista; abdomen with 5 or 6 visible segments; 4 posterior veins in wing between apex of third vein and apex of second branch of cubitus, the first cubital branch arising from the second basal cell.

#### HABITS OF LARVAE

The larvae are aquatic, their food consisting of algae, decaying vegetable matter, and minute organisms such as crustaceans.

#### HABITS OF IMAGINES

The flies are invariably flower-frequenters, occurring in large numbers on Umbelliferae, etc.

#### KEY TO GENERA

##### LARVAE AND PUPARIA

1. Apieal abdominal segment very much elongated, more than 3 times as long as its greatest width; penultimate and antepenultimate ventral segments without curved thorns; antennae about three times as long as their diameter. .... *Stratiomyia*.
- Apieal abdominal segment at most 3 times as long as its basal width; penultimate and antepenultimate ventral segments, or only the former, with 2 or 4 strong curved thorns on their posterior margins; antennae about 6 times as long as their diameter. .... *Odontomyia*.

#### STRATIOMYIA Geoffroy

##### GENERIC CHARACTERS

*Larva and Puparium* (Pl. XLVII, Fig. 1).—Elongate, slightly tapering anteriorly; the head elongate, antennae short. Posteriorly the body is usually much attenuated, the last segment being more than 3 times as long as its greatest width; no curved thorns on ventral segments; dorsum with or without surface hairs, but without the well-defined transverse series of 6 bristles so noticeable in Geosarginae and Pachygasterinae, and without curved thorns on posterior margin of antepenultimate and penultimate segments ventrally.

*Imago*.—Robust, black species, with conspicuous yellow, greenish, or whitish markings. Abdomen with 5 or 6 visible segments; third antennal joint without a differentiated arista; 4 posterior veins present on wing, 3 of which arise from discal cell; third vein forked; scutellum spinose; basal joint of antennae at least 3 times as long as second.

#### HABITS OF LARVAE

The larvae are aquatic, occurring in ponds and slow-flowing streams. Their food consists of decaying vegetation and minute organisms—such as algae, diatoms, and crustaceans. Species that I have kept in the laboratory fed upon decaying leaves, eating all but the veins and main ribs. The skin of the larvae is very tough and, except just after molting, covered with a sedimentary deposit which serves to conceal the species on the mud bottoms where they occur. They become conspicuous, however, when they crawl out of the water on the muddy banks, as their skins dry out rapidly and become grayish, so that they are readily seen against the darker ground. The larvae stand drying out remarkably, some of those I had recovering upon being placed in water even after they appeared to be hard and lifeless. This faculty of recovery must prove of great value to the species which occur in shallow ponds or in streams which dry up during periods of summer drought.

#### HABITS OF IMAGINES

The flies are usually found on flowers of various plants, and are particularly common upon wild parsnip and wild carrot.

#### KEY TO LARVAE AND PUPARIA

1. Prothorax with slender hairs on its anterior margin; apical segment about 6 times as long as its basal width. .... *norma*.
- Prothorax with a number of short, stout processes on its anterior margin in addition to the slender hairs; apical segment about 3 times as long as its basal width. .... *meigeni*.

#### STRATIOMYIA NORMA Wiedemann

*Stratiomyia norma* Wiedemann, Aussereur. Zweifl. Ins., Vol. 1, p. 62. (1828)

*Larva* (Pl. XLVII, Fig. 1).—Length, 30–40 mm.; greatest diameter, 5.6 mm. Dorsum with 6 indistinct pale vittae and pale spots at bases of the slender surface hairs, lateral margins pale.

Head as in Figures 1 and 2, Plate XLVIII, the antenna not over 3 times as long as its apical diameter (Fig. 6, *a*) ; maxillae very complex (Fig. 3) in life, moving rapidly and alternately with an upward and downward motion; mandibles weak (Fig. 6). Entire body with rather long weak hairs, a pair on lateral margins, and 6, stronger than the others, in a transverse series on disc of each segment; apical segment about 6 times as long as its basal width, the terminal hairs of moderate length.

The foregoing description was made from material obtained in the Illinois River and used by Mr. Hart in connection with his paper previously referred to. The species is very common in the Illinois and connected rivers and streams.

For a more complete description of the external appearance of the larva and details of the life history of the species the reader is referred to Mr. Hart's paper.\*

#### STRATIOMYIA MEIGENI Wiedemann

*Stratiomyia meigeni* Wiedemann, Aussereur. Zweifl. Ins., Vol. 1, p. 61. (1828)

*Larva*.—Length, 25 mm.; greatest width, 5 mm. Darker than the preceding species, the pale vittae distinct only at posterior margin of each segment.

Differs from *norma* in having a number of short, stout processes on anterior margin of dorsum of first segment, and in the length of the apical segment—which is but little more than 3 times as long as its basal width and more gradually tapered than in *norma*.

Described from specimens obtained in a small stream at Muncie, Ill., in April and May, 1916.

I had many larvae but reared only 2 imagines. The species is very common throughout the state, and the imago has been previously recorded by Mr. Hart, under the name *marginalis* Loew, from Bureau, Rock Island, McLean, and Champaign counties. It occurs commonly on flowers of wild parsnip in August at White Heath, Urbana, and Muncie.

#### ODONTOMYIA Meigen

*Larva and Puparium* (Pl. XLVII, Figs. 2, 3).—Similar in general appearance to *Stratiomyia*, but differs in the following particulars: the antennae are longer—about 6 times as long as their apical width; the apical segment is not more than 3 times as long as its basal width

\*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, pp. 248-252. (1895)

and but slightly tapered; and the penultimate segment—sometimes the antepenultimate also—bears 2 or 4 curved thorns on the posterior margin of the ventral surface.

#### HABITS OF LARVAE

The larvae are aquatic, living in streams, particularly in those with slow current and muddy bottom. Their food consists of algae, small crustaceans, and decaying vegetable matter.

#### HABITS OF IMAGINES

The flies are commonly found on flowers along the margins or in the immediate vicinity of streams.

#### KEY TO LARVAE

1. Dorsum with 6 pale vittae, which are usually so close together as to give the appearance of a single longitudinal band that tapers posteriorly; large species, 20–30 mm. in length. .... *cincta*.
- Dorsum with 6 pale vittae which are rather widely separated and do not form a longitudinal pale band; smaller species, 12–15 mm. in length. .... *vertebrata*.

#### ODONTOMYIA CINCTA Olivier

*Odontomyia cincta* Olivier, Encycl. Méth., Vol. 8, p. 432. (1811)

*Odontomyia extremis* Day, Proc. Acad. Nat. Sci. Phila., 1882, p. 80.

The larva (Pl. XLVII, Fig. 3) of this species has been described by Mr. Hart\*. I have dissected the head and find that the maxillae and mandibles differ from those of *Stratomyia norma* as shown in Figures 3 and 6 and 5 and 7, Plate XLVIII. The larvae may also be distinguished from *Stratiomyia* as indicated in the key to genera.

The species is represented in our collection by many larvae, mostly obtained in the Illinois River. Most of the imagines were taken in the vicinity of the Sangamon and Illinois rivers, but a few were obtained at Muncie, near some small streams where the larvae were found.

#### ODONTOMYIA VERTEBRATA Say

*Odontomyia vertebrata* Say, Appendix to Vol. 2 of Keating's Narrative of an Expedition to the Source of St. Peter's River, etc., p. 369. (1824)

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\*Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI, pp. 260–261.

This species occurs generally throughout the state, and in fact in most parts of North America. The larva (Pl. XLVII, Fig. 2) is found in rivers and small streams, and differs from that of *cincta* in its smaller size and in the markings, as stated in key. For fuller descriptions and life histories of the two species see Mr. Hart's paper previously cited.

I have found the larvae abundant in a small stream at Muncie from April to June.

### Subfamily CLITELLARIINAE

This subfamily does not, in my opinion, form a natural group. I consider that *Hermetia* does not properly belong with the aquatic forms, being more closely allied to Geosarginae in larval characters, but I leave the arrangement as in Williston's "Manual" pending further information upon the life history of other genera.

#### SUBFAMILY CHARACTERS

*Larva and Puparium.*—The larvae of the aquatic forms differ from those of Stratiomyiinae in having the apical segment comparatively shorter, almost subquadrate, and the dorsum with short thick bristles arranged in a transverse series near posterior margin of each segment except the apical. The genus *Hermetia* is terrestrial, resembles the larva of *Geosargus* in many respects (though much larger than any species of that genus known to me), and has the body slightly broadened apically, the dorsum unicolorous, and the head long and tapered anteriorly.

#### KEY TO GENERA

##### LARVAE AND PUPARIA

1. Terrestrial species; body not tapered posteriorly; apical segment rounded; opening of the posterior spiracular chamber in the form of an unfringed transverse slit at apex of dorsum of last segment ..... *Hermetia*.
- Aqnatice species; body tapered anteriorly and posteriorly; apical segment elongated and more or less trunuated; opening of posterior spiracular chamber fringed with soft hairs. .... 2
2. Posterior spiracular chamber situated on dorsum of apical segment; the fringe of hairs rather short; apical segment armed with 4 long marginal hairs ..... *Nemotelus*.
- Posterior spiracular chamber at apex of apical segment, the fringe of hairs long; apical segment without the long marginal hairs. .... *Oxycera*.

## HERMETIA Latreille

I have before me one larva and several puparia of a species of this genus. It is probable that the generalization given below will apply to all species of the genus.

## GENERIC CHARACTERS

*Larva and Puparium*.—Head long, tapered anteriorly; antennae distinct but short, rather slender. Body broad, of nearly uniform width except apically, where it becomes slightly broader; surface with many short hairs, and a number of long bristles in almost straight transverse series; lateral bristles long, simple; apical segment very similar to that of *Geosargus*, the marginal bristles long; respiratory chamber terminal. Abdomen with distinct lateral spiracles on segments 1-7.

## HERMETIA ILLUCENS Linné

*Musca illucens* Linné, Syst. Natur., ed. 10, Vol. 2, p. 979. (1758)

*Larva and Puparium* (Pl. XLVIII, Fig. 13).—Length, 16-18 mm.; greatest width, 5 mm. Dark brown, head yellowish, dorsum unstriped.

Head long and rather narrow, the surface hairs short, arranged on dorsum as in Figure 10, Plate XLVIII; antennae short and stout, apical joint about as long as basal but much thinner. Body covered with fine short hairs and with long bristles arranged as in Figure 10; spiracles on prothorax much larger than the lateral abdominals; only 2 long bristles on sides of each thoracic segment when seen from above. Abdomen becoming broader posteriorly; spiracles distinct on segments 1-7, segments 2-5 with a small round wart just posterior to each spiracle; apical segment longer than preapical, armature of venter as in Figure 11; respiratory chamber terminal.

Described from specimens sent me by L. H. Dunn—which were found in 1915 feeding upon the dead body of a man in a jungle about three miles from one of the settlements in the Panama Canal Zone—and one specimen taken by C. A. Hart at Galveston, Texas.

Under the name *H. mucens*, Riley and Howard recorded the larvae as living upon wax, etc., in beehives\*; and larvae supposed to belong to this species are recorded by Morgan† as occurring in the alimentary canal of man. He also states that they have been found

\*Insect Life, Vol. 1, 1899, p. 353.

†Bull. 48, sec. ser., Louisiana Agr. Exper. Station, p. 151. (1897)

in catsup and decaying vegetables and reared from potatoes. The larvae are numerous in privies in the Southern States and in Central America.

### NEMOTELUS Geoffroy

I have not seen the larva of any species of this genus. Lundbeck\* has described and figured the larva of the European *pantherina*, which agrees in general characters with *uliginosus*, also of Europe, previously described by Haliday†.

The characters that serve to separate the larvae of *Nemotelus* from those of *Oxycera* are given in the key to the larvae of this subfamily (Clitellariae).

The larvae are aquatic, and although unknown to me must be common in suitable situations throughout the state, since in the imaginal stage at least one species commonly occurs from June to August on various flowers.

### OXYCERA Meigen

#### GENERIC CHARACTERS

*Larva and Puparium*.—I have found only one larva that I considered as belonging to this genus, and unfortunately it was not preserved when it died. Lundbeck's description of the larva of *trilineata* is the best available, and the following data are drawn from his paper.‡

Head conical, with small eye-spots on the anterior part and small antennae anterior to them. Segments broader than long, only the apical one a little longer than broad, rounded behind. Dorsum with stout bristles which are thickened apically, arranged in pairs, 2 pairs on each side of median line, the median pairs close together, and in addition to these bristles, which are near the posterior margin, several appear laterad of them and also a transverse series of much shorter bristles near anterior margin; lateral margins with a pair of strong bristles on each segment, including the apical one. Posterior spiracular chamber at apex, fringed with long hairs; abdominal segments 1 to 6 with rudimentary lateral spiracles.

\*Diptera Daniea, Part I, p. 23. (1907)

†Nat. Hist. Rev., No. III, 1857, p. 194.

‡Diptera Daniea, Part I, p. 31. (1907)

## HABITS OF LARVAE

The larvae are aquatic, occurring along with and having the same habits as those of *Stratiomyia* and *Odontomyia*.

## HABITS OF IMAGINES

The flies are rarely taken except by sweeping amongst vegetation on the margins of streams or ponds, or on marshy ground. I have not found them on flowers. One species I have taken in numbers on the leaves of bracken (*Pteris*) in Europe.

As there is no synopsis of the species of this genus for North America the following key and revision is presented as an aid to students.

## KEY TO SPECIES

## IMAGINES

1. Thorax with 2 yellow lines on dorsum in addition to the pair on upper margins of pleurae.....2
- Thorax with 4 yellow lines on dorsum in addition to the pair on upper margins of pleurae.....3
2. Femora in part black.....*centralis* (p. 326).
- Femora entirely yellow.....*approximata* (p. 326).
3. Abdomen with a complete yellow fascia on third segment in addition to the usual lateral spots.....*variegata* (p. 327).
- Abdomen with at most 3 spots on third segment, one in center and one on each side.....4
4. Central spot absent from third abdominal segment; legs with black markings; large species, 8 mm.....*crotchi* (p. 328).
- Central spot present on third abdominal segment; legs, with the exception of the coxae, yellow; smaller species, about 5 mm.....5
5. Fourth abdominal segment with 2 small spots on center, the lateral pale marks very distinctly curved forward and widely separated; veins surrounding discal cell of wing distinct.....*aldrichi* (p. 329).
- Fourth abdominal segment without spots except the laterals; veins enclosing discal cell indistinct.....6
6. The pale markings whitish; lateral stripes on frons very slightly incurved at upper extremity, not connected there (female).....*albovittata* (p. 330).
- The pale markings sulphur- or lemon-yellow; lateral stripes on frons distinctly incurved and connected with each other at their upper extremities (female).....*picta* (p. 331).

## OXYCERA CENTRALIS Loew

*Oxydera centralis* Loew, Berl. Ent. Zeitschr., Vol. 7, 1863, p. 8.

This species is somewhat similar to *approximata*, differing in having the antennae black, the pleurae immaculate, and the legs, especially the femora, with black markings.

Originally described from Red River of the North, and not subsequently recorded as far as I am aware.

## OXYCERA APPROXIMATA, n. sp.

*Male*.—Glossy black, with lemon-yellow markings. Head black, sides of frons with a silvery line which is connected with one on sides of face, the latter becoming abruptly narrowed on its lower third; mouth parts yellow; posterior eye-orbits silvery; antennae orange, apical joint (6th) and arista brown. Thorax with 2 yellow vittae near lateral margin which extend from humeral spot to suture and slightly beyond, and are occasionally connected with a large irregular spot on posterior lateral angles of disc; another yellow line, connected with the sublateral one by the humeral spot, extends along the upper margin of pleurae to wing-base, where it becomes conspicuously broader; below the expanded posterior portion of the lateral line is a large yellow spot, and slightly caudad of the latter and situated higher on the side is a smaller one; scutellum black, margin narrowly yellow, thorns yellow, blackened at apices. Base of abdomen with a yellow spot which extends laterad anteriorly in the form of a slender line; third segment with a pair of approximate spots on anterior half and an oblong spot on postero-lateral angle; fourth segment with an oblong spot on postero-lateral angle which is smaller than that on the preceding segment; fifth segment with the posterior margin rather broadly yellow; lateral spots usually carried more or less distinctly along the extreme lateral margins of segments; venter black. Legs yellow; coxae black. Wings clear, veins yellowish. Halteres lemon-yellow.

Eyes contiguous; antennae rather short, not longer than arista. Thorax with short brownish discal hairs; scutellar thorns of normal size. Abdomen with rather sparse short pale hairs. Legs normal in structure. Cross vein furcate, the fork forming almost a right angle; the 4 veins leaving discal cell indistinct.

*Female*.—Differs from the male in having the 2 approximated spots on third abdominal segment smaller and separated, and in the color and structure of the head as follows: frons one third the width

of head, glossy black, a conspicuous yellow line on each side extending from base of antennae somewhat above middle of frons, its upper portion being separated from the eye-margin by a narrow black line; face glossy black, slightly yellowish on each side, and with a conspicuous silvery, pilose, stripe which extends beyond the lower extremity of the yellow line on frons; posterior eye-orbits conspicuously yellow. In other respects as in the male.

Length, 5 mm.

Type locality, Muncie, Illinois, July 5, 1914 (J. R. Malloch). Allotype (male), Lafayette, Indiana, June 23 (J. M. Aldrich).

The type specimen was taken by sweeping vegetation on the bank of Stony Creek. The allotype is in the collection of Prof. J. M. Aldrich; the type, in the collection of the Illinois State Laboratory of Natural History.

This species is closer in general appearance to *centralis* Loew than to any described North American species, but may be readily separated from it by the entirely yellow legs, the greater amount of black on scutellum, and the presence of pleural spots, as well as by other characters.

#### OXYCERA VARIEGATA Latreille

*Oxydera variegata* Latreille, Eneyel. Méth., Vol. 8, p. 600. (1811)

*Oxydera variegata* (Olivier) Macquart, Dipt. Exot., Vol. 1, Pt. II, p. 191. (1838)

*Oxydera unifasciata* Loew, Berl. Ent. Zeitschr., Vol. 7, 1863, p. 9.

*Male*.—Black, shining, with conspicuous lemon-yellow marks. Head black; frons with a lateral line of white pilosity which connects with a similar line on sides of face, the latter abruptly narrowed on lower portion; face with 2 yellow spots below bases of antennae; mouth parts yellow; antennae reddish yellow, apical joint (6th) and arista brownish; occiput and anterior eye-orbits black. Thoracic vittae yellow, 4 in number, submedian pair slightly dilated anteriorly, and with a perceptible outward curve, occasionally connected with the sublateral pair, interrupted at suture, the portion beyond suture subtriangular and extending to posterior margin of disc; sublateral vittae broader than submedian pair, slightly dilated anteriorly, at suture, and posteriorly, connected with lateral stripe by humeral spot; pleurae with 2 spots on posterior portion; scutellum black only on extreme anterior margin and apices of thorns. Abdomen black; a large oblong spot on base of dorsum, a small lateral spot on sides of second segment, a complete fascia (which is slightly emarginate on posterior margin) on third segment, a large oblong spot on fourth

segment, and the greater portion of fifth segment yellow, these markings being connected by means of a narrow yellow marginal line; venter with a conspicuous oblong yellow spot on lateral margins of each segment. Coxae black, legs yellow. Halteres yellow.

Eyes contiguous; antennae short, barely longer than arista. Thoracic hairs yellow, particularly noticeable on anterior central portion; scutellum shorter than the thorns. Legs normal. Fork of third vein at right angles to that vein; the 4 veins leaving discal cell indistinct.

*Female*.—Differs from the male in the color and structure of the head as follows: frons glossy black, about one third the head-width, almost parallel-sided, in profile distinctly higher than eyes, a more or less distinct suture or depression visible on center, a rather broad yellow line on each side, extending from a short distance above the antennae to the anterior ocellus, dilated at its lower extremity, where it almost touches the eye-margin, of nearly uniform width throughout the remainder of its length, and separated from the eye-margin by a space equal to its own width, the space between slightly increased at the upper extremity; face as in male but the yellow spots larger; posterior eye-orbits yellow, blackened slightly below and separated from the large yellow vertical spot by a narrow black line. In other respects as the male.

Length, 3.5-4 mm.

Originally described from Carolina. Loew described the same species, under the name *unifasciata*, from Pennsylvania. Melander has recorded *unifasciata* from Virginia and Illinois. I have seen specimens from Monticello, Illinois (Hart and Malloch) and Lafayette, Indiana (J. M. Aldrich), taken in June and July.

#### OXYCERA CROTCHI Osten Sacken

*Oxyceera crotchi* Osten Sacken, Western Diptera, p. 212. (1877)

Original description: “*Oxyceera crotchi* n. sp., ♀.—Abdomen with three lateral yellow spots on each side and an apical triangular one, all connected by a narrow yellow margin; femora black, with yellow tip; tibiae and tarsi yellow. Length 8 mm.

“*Female*.—Face and front yellow, with a broad black stripe in the middle; posterior orbits yellow; vertex, cheeks under the eyes, and occiput black. Antennae: basal joints black (the rest wanting). Thorax black, opaque; a yellow stripe from the humerus to the antescutellar callus is interrupted a little beyond the middle, a pair of nar-

rower yellow stripes on the dorsum slightly expanded in front and not reaching beyond the transverse suture; scutellum yellow, the base black; pleurae with a large yellow spot in front of the wings, and a smaller oblong one under it; the black opaque abdomen has a subtriangular yellow spot on each side of the second segment, a larger, semi-elliptical spot on each side of the third segment, a somewhat similar, but smaller, pair of spots on the fourth segment, a large triangular spot on the last segment; all these spots are connected by the narrow, yellow, abdominal margin; ventral segments yellow in the middle, brownish black on the sides. Femora black with yellow tips; tibiae and tarsi yellow; joints 3 or 4 of front tarsi darker. Wings tinged with yellowish anteriorly, with grayish posteriorly; stouter veins and stigma reddish yellow.

"Hab.—California (G. R. Crotch). A single specimen."

This species may belong to the genus *Euparyphus*; the third joint of the antennae—the best character for the separation of the genera—was missing from the type. I have not seen any specimens either of *Oxycera* or *Euparyphus* that agree entirely with Osten Sacken's description, though two males of a species of *Euparyphus* in Professor Aldrich's collection from Idaho and Colorado agree fairly well with it. The submedian yellow thoracic vittae do not extend much beyond the suture in these specimens, but the third vein is unforked—a character that it is improbable Osten Sacken would overlook. The length given for *crotchi*, 8 mm., exceeds that of any other member of the genus *Oxycera* from North America.

Originally described from California and not subsequently recorded.

#### OXYCERA ALDRICHI, n. sp.

*Male*.—Black, shining, with lemon-yellow markings. Head black; face with a white pollinose line on lateral margins which extends along the sides of frons, and 2 yellow spots below bases of antennae; antennae apically brown; mouth parts yellow. Thorax with the same yellow markings as in *variegata*. Abdomen with the following yellow markings: a large basal spot which is slightly narrowed posteriorly, a larger similarly shaped transverse spot on middle of third segment, a pair of minute rounded submedian spots on fourth segment, a large subtriangular spot on fifth, a small lateral spot on second, a large anteriorly curved one on lateral margins of third and a narrower similarly curved one on fourth; venter black, the lateral margins yellow. Coxae black, legs reddish yellow. Wings clear, veins yellow. Halteres lemon-yellow, stems reddish.

Structurally as the male of *variegata*, but the veins enclosing the discal cell are much more distinct.

Length, 4.5 mm.

Type locality, Lafayette, Indiana, June 23 (J. M. Aldrich).  
Named in honor of the collector.

OXYCERA ALBOVITTATA, n. sp.

*Female*.—Black, shining, with conspicuous whitish markings. Head black; frons with a white line on each side from anterior ocellus to antennae, touching the eye-margin on the lower third and separated from it on the upper two thirds by a space subequal to its own width, not incurved above, connected with the white, pilose lateral face-stripe at base of antennae, the latter not abruptly narrowed below, gradually tapering; face with the exception of the lateral lines black; posterior orbits white, except a portion along eye-margins on upper half, separated from the white spot on vertex by a narrow black line; mouth parts whitish yellow; antennae reddish, basal two joints whitish, apical joint brown. Thorax with the same pale markings as *variegata*; base of scutellum and basal angles black. Abdomen with the following creamy white markings: a transverse spot at base, produced caudad in center, a moderately large oblong spot on center of third segment which is rounded posteriorly, the entire apical half of fifth segment, and a spot on lateral margins of second, third, and fourth segments, all of the marginal spots connected by means of the narrow marginal whitish line, the spot on each side of third segment larger than the others; venter black, marginal spots showing slightly. Coxae black, legs flavous. Wings clear, veins yellow. Knob of halteres white, stem brownish. Hairs on body whitish.

Frons slightly broader than eye-width, slightly raised on each side of the median line, this line and the lateral edges slightly impressed; antennae rather elongate, arista not longer than the composite third segment (3-6); posterior orbits rather broad. Thorax distinctly punctured, discal hairs rather short. Abdomen and legs of normal form. Vein closing apex of discal cell in vertical line with apex of stigma; the portion of costa from apex of stigma to fork of third vein distinctly longer than that from fork of third vein to apex of third.

Length, 5 mm.

Type locality, Muncie, Illinois, July 5, 1914 (J. R. Malloch).

## OXYCERA PICTA Van der Wulp

*Oxyceria picta* Van der Wulp, Tijdschr. v. Entom., Vol. 10, 1867, p. 133.

A male which I believe belongs to this species differs from the foregoing description in having the pale markings lemon-yellow and considerably larger. The antennae are shorter, not exceeding the length of the arista, and the entire length of the specimen is 5.5 mm.

Locality, Urbana, Illinois, June 7, 1901 (C. A. Hart).

Van der Wulp had some doubts as to the identity of his species with that described by Latreille as *maculata*, since many essential characters were not mentioned by that author, and Macquart in his redescription of the type did not make matters much better. From *albovittata* the female of *picta* may be separated by the sulphur-colored markings, and by the fact that the lateral frontal stripes curve inwards above and connect with each other and with a pale line round the ocelli. It is possible that Van der Wulp had two species mixed, as he says that there are sometimes 2 yellow spots below the antennae—a character that I am inclined to believe is not by any means variable, and one which is absent from the male described above. *Picta* was originally described from Wisconsin. Melander has recorded *maculata* from Louisiana, but the record may refer to *picta*.

## Subfamily BERIDINAE

I have not seen the larva of any species of this subfamily. My only information as to the characters of this stage is derived from European authors, and is included in the key to the subfamilies of Stratiomyiidae.

The larvae are terrestrial in habit. In general appearance they resemble those of *Geosargus*, but differ in having the bristles on the dorsum and lateral margins short and closely placed in groups of 4 or more.

The imagines are very rarely met with in North America—a fact quite in contrast with conditions in Europe, where several species are among the very commonest of any in the family.

## Subfamily GEOSARGINAE

This subfamily contains nine distinguishable genera. Williston gives ten in his "Manual", but there is no valid reason for separating *Macrosargus* from *Geosargus*. I have obtained the larvae of two genera, which are described herewith.

## SUBFAMILY CHARACTERS

*Larva and Puparium*.—Head elongate; antennae distinct but short. Body broad, almost parallel-sided, slightly narrowed anteriorly, rounded posteriorly, with distinct vittae; segments distinct; dorsal segments with a transverse series of 6 strong bristles; lateral margins of each segment except the apical one with 2 bristles; ventral segments with bristles similar to but weaker than dorsal series; spiracular chamber transverse, situated on disc of apical segment near apex; apical segment with a number of long marginal hairs and a few on disc.

*Imago*.—Antennae short, with an apical or dorsal arista; abdomen with 5 or 6 visible segments; discal cell emitting 3 veins.

## KEY TO GENERA

## LARVAE

1. Pale stripes on disc of dorsal segments geniculated on each segment ..... *Geosargus*.
- Pale stripes on disc of dorsal segments straight ..... *Microchrysa*.

## GEOSARGUS Bezzi

This genus is synonymous with *Sargus* of Aldrich's Catalogue, *Sargus* Fabricius being preempted by *Sargus* Walberg.

## GENERIC CHARACTERS

*Larva and Puparium*.—The larva differs from that of *Microchrysa* in the shape of the head, which is much shorter in comparison with its width than in that genus.

*Imago*.—Brilliant metallic blue or green flies, with slender bodies and unspined scutellum.

## HABITS OF LARVAE

The larvae are scavengers, feeding on decaying vegetation and manure.

## HABITS OF IMAGINES

Commonly found on leaves of trees and bushes, especially if in the sunshine, and particularly on such trees or bushes as border pastures.

One species, *nubeculosus* Zetterstedt, was introduced into North America from Europe. It has been recorded as feeding in the larval stage on decaying turnips and other root-crops.

## GEOSARGUS VIRIDIS Say

*Sargus viridis* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 87.

*Larva and Puparium* (Pl. XLVIII, Fig. 16).—Length, 9 mm.; width across dorsum at middle, 3 mm. Brownish testaceous, dorsal surface with a dark grayish brown, slightly irregular, waved stripe on each side of the middle line, the area laterad of the line occupied by 2 rather less distinct stripes of the same color, which are slightly fused and irregular, the whole dorsum having the appearance of being six-striped, the median pair of stripes more or less distinctly connected near anterior margin of each segment and enclosing 2 small spots near posterior margin, the ventral surface similarly marked. Head with only 2 brown dorsal lines; tips of maxillary palpi, mandibles, and antennal base dark brown.

Head slightly longer than broad, armed as in Figure 8, Plate XLVIII; surface of thoracic and abdominal segments finely shagreened (Fig. 16, b), the armature as shown in the same figure; spiracular depression in the form of a deep transverse slit, situated very close to apex of segment; ventral segments with armature similar to that of dorsal; apical ventral segment as in Figure 12.

Described from examples obtained in cow manure at Muncie, Ill., in April, 1916. The larvae are very sluggish. The first example of the imago emerged in the laboratory a month after being brought in from the field.

The species is common everywhere in Illinois, and in fact all over the United States.

## GEOSARGUS sp.?

I have before me a number of larvae of a species of *Geosargus* that differ from *viridis* in having the head longer—more resembling that of *Microchrysa polita*—and also in the striping of the dorsum, the central dark stripe consisting of a series of diamond-shaped spots—one on each segment—instead of a divided stripe as in *viridis*. In other respects the larvae agree closely.

I have a suspicion that the color of these specimens may not be that of fully matured larvae, as they had previously undergone very considerable changes, being whitish testaceous and without distinct vittae and almost devoid of bristles when young, developing the vittae and bristles as they matured. If they had overwintered safely they might have assumed the coloring and structure which would have proven them to be *viridis*, but as it is I can not definitely decide their specific status.

The species was obtained by me at White Heath, Ill., June 24, 1916, from horse dung.

### MICROCHRYSA Loew

#### GENERIC CHARACTERS

*Larva and Puparium*.—Very similar to the larva of *Geosargus*, differing as indicated in generic key, and in having a longer head.

*Imago*.—Brilliant metallic blue species, with rather stout bodies.

#### HABITS OF LARVAE

The larvae feed upon manure or decaying vegetation. The species hibernate as larvae.

#### HABITS OF IMAGINES

The flies have similar habits to those of *Geosargus*.

### MICROCHRYSA POLITA Linné

*Musca polita* Linné, Fauna Suecia. (1761)

*Larva and Puparium*.—Length, 5–6 mm. Differs from *Geosargus viridis* in having the two pale stripes on dorsum entirely straight and the central dark line complete.

Head more slender anteriorly than in *G. viridis* (Pl. XLIX, Fig. 2). Armature similar to that of *viridis* except that the bristles are much longer. Apical segment more attenuated apically than in *Geosargus*, the respiratory opening much smaller, not in the form of a transversely elongated slit, and farther from apex than in that genus (Pl. XLIX, Fig. 3).

Described from specimens from which imagines were obtained by the writer. The larvae were found in company with those of *Geosargus viridis* in cow manure at Muncie, Ill., in April, 1916. They closely resemble the larva of *Geosargus*, but the difference in the dorsal markings readily separates the two.

The imagines are not nearly so common as those of *Geosargus viridis*.

#### Subfamily PACHYGASTERINAE

I recently published a revision of the imagines of this subfamily\*, and students may refer to that for full information regarding species.

\*Ann. Ent. Soc. Amer., Vol. 8, 1915, pp. 305–320.

The present paper deals only with the early stages and additional data bearing upon the occurrence of Illinois species.

#### SUBFAMILY CHARACTERS

*Larva and Puparium.*—Very similar in general appearance to the larvae of Geosarginae; but all species that I have seen, differ in having no distinct color-markings on dorsum, the body being uniformly testaceous or brownish. The head is also noticeably more elongated and the body narrower in comparison with its length. The armature of the body varies throughout the subfamily, but the bristles are always conspicuous—though sometimes of unequal length—the surface is shagreened as in other subfamilies, and there are no evident decumbent hairs. The apical segment is similar to that of Geosarginae. The lateral abdominal spiracles are very small, or indistinguishable.

#### KEY TO GENERA

##### LARVAE AND PUPARIA

1. Abdominal bristles very long, those on lateral margins, and on posterior margin of apical segment particularly so, the latter of uniform length and as long as or nearly as long as width of segment.....<sup>2</sup>
- Abdominal bristles short, those on margin of apical segment not more than half as long as width of segment, some of them very short.....*Neopachygaster*.
2. Outer bristle of each transverse series on dorsal abdominal segments minute, not more than a sixth as long as next bristle, the latter very much longer than inner pair.....*Eupachygaster*.
- Outer bristle of each transverse series on dorsal abdominal segments about half as long as next bristle, the latter not very much longer than inner pair.....*Zabracchia*.

#### NEOPACHYGASTER Austen

I have before me a large series of larvae and empty puparia of *maculicornis* Hine, the only species in North America so far assigned to this genus.

#### GENERIC CHARACTERS

*Larva and Puparium.*—Head very much longer than its greatest width, much tapered anteriorly; antennae very short; surface hairs long. Body narrower than in *Zabracchia* and *Eupachygaster*, the bristles comparatively shorter.

## NEOPACHYGASTER MACULICORNIS Hine

*Pachygaster maculicornis* Hine, Ohio Nat., Vol. 2, 1902, p. 228.

*Larva and Puparium*.—Length, 3-4 mm. Pale testaceous, unmarked.

Head similar to that of *Eupachygaster henshawi* in general appearance, the bristles noticeably shorter. Armature of body similar in arrangement to that of *henshawi* but the bristles much shorter, their relative lengths on penultimate and ultimate segments as in Figure 6, Plate XLIX.

The larvae of which the foregoing is a brief description, were obtained under the bark of fallen elm-trees at White Heath, Ill., in March and April, 1916. I reared a large number of imagines from the larvae, and have also many of the latter alive in the laboratory now (January, 1917) which I took under similar conditions in the forestry of the University of Illinois October 21 and 28, 1916. The larvae feed upon decaying matter under the slightly loosened bark, but also, occasionally, on other dipterous larvae—as on those of *Lonchaea polita*, which are found along with them. *Lonchaea* larvae often eat other larvae and puparia—as do also those of *Euxesta*, which frequents the same habitat—in fact the dipterous larvae found under bark under conditions suitable for Stratiomyiidae appear to be almost without exception alternately predaceous or saprophagous. They may be able to live entirely upon the sap and slightly decayed vegetable matter under the bark but I suspect that the main food supply consists of excreta, exuvia, or the bodies of coleopterous larvae that occur there. That they feed upon each other I have proven by personal observation.

## EUPACHYGASTER Kertész

I obtained a single larva of this genus under the loose bark of an apple-tree at Savoy, Ill., May 4, 1916, from which I succeeded in rearing a female imago. A comparison of the larva when found with a figure of that of *Eupachygaster tarsalis* Zetterstedt convinced me that I had one that was congeneric with that species, and as I had provisionally placed but one North American species in that genus I was particularly anxious to discover whether my diagnosis of the imagines was correct. I was therefore much gratified to find that the resultant imago agreed generically with the species I had placed in this genus.

I subsequently obtained many larvae of the genus at Urbana, most of which are still alive (January 1917).

## GENERIC CHARACTERS

*Larva*.—Head elongate, tapering anteriorly, the portion anterior to eyes distinctly longer than its greatest breadth; surface hairs long. Segments of body well differentiated; each dorsal segment with 6 hairs in a transverse series beyond middle, the outer one on each side very short, the middle one very long, and the inner shorter than the latter but much longer than the outer; lateral margin of each segment with a pair of hairs, the anterior one very short, the posterior one very long; hairs on apical segment long and equal, the segment rounded posteriorly; ventral segments, excepting the apical one, each with 6 subequal hairs in a transverse series.

*Imago*.—Antennae short, third joint disc-like; arista very short-haired; eyes large, with vertical color-bands, those of the female rather widely separated, those of the male narrowly so. Thorax with decumbent silvery pile; scutellum with a posterior marginal ridge. Abdomen short, rounded, subglobose. Third vein of wing furcate.

## HABITS OF LARVAE

The larvae are found under bark of trees that has become slightly loosened. They feed upon the sap and upon insect larvae and are very sluggish.

## HABITS OF IMAGINES

The flies frequent leaves of trees in the sunshine, and are very deliberate in their movements, walking slowly, but they take flight suddenly, though they fly rather heavily as compared with most members of the subfamily.

I know of no parasites of any stage in this genus.

## KEY TO IMAGINES

1. Arista with very dense whitish pubescence which gives it the appearance of being thickened; third antennal joint disc-like; scutellum not regularly convex on disc, the center with a slight hump; pile on sides of mesonotum arranged in small punctiform groups. .... *punctifer*.
- Arista with very little pubescence, appearing filiform; third antennal joint much higher than long; scutellum regularly convex on disc; pile on sides of mesonotum arranged in irregular short stripes. .... *henshawi*.

## EUPACHYGASTER PUNCTIFER Malloch

*Eupachygaster punctifer* Malloch, Ann. Ent. Soc. Amer., Vol. 8, 1915, p. 316.

The eyes are marked and colored as in *henshawi* except that the anterior margin does not have a distinct stripe and that the other stripes are broader, the violaceous blue one continuing almost to the lower margin. The thorax has a central narrow stripe of silvery pile, the lateral portions of the disc being adorned with punctiform groups of similar pile. The basal half of the abdomen is devoid of punctiform groups of silvery pile.

This species was described from a single female specimen taken by Dr. Nason at Algonquin, Ill., which bears no date of capture.

The other specimen referred to in the notes on this species given under the original description belongs to the next species. I took a female example of *punctifer* in a wood near an old orchard at White Heath, Ill., June 24, 1916.

## EUPACHYGASTER HENSHAWI, n. sp.

*Larva*.—Length, 7 mm. Dark brown, shining, head and lateral margins of segments paler.

Head as in Figures 4 and 5, Plate XLIX; antennae small, pointed, located on disc well back from lateral margin; dorsal and ventral armature as in figures. Armature of dorsum of thorax and abdomen as in Figure 9 (puparium); thoracic segments on their ventral surface with 6 hairs in a transverse series, the outer two on each side of each segment contiguous basally; ventral abdominal segments each with a transverse series of 6 long hairs, the outer one on each side of each series longer than the others, each series occupying about half the width of segment; anal opening elongate, with 2 short hairs on each side close to margins of the opening; disc of apical segment with 2 long hairs, one on each side before middle and about midway from anal opening to lateral margin. All hairs microscopically pubescent.

*Imago; Female*.—Black, very distinctly shining. Frons and face shining black, the center of former slightly obscured by the presence of a number of piliferous punctures; a conspicuous stripe of silvery pile, beginning above antennae on lateral margins of frons, extends down over sides of face to lower margin of eyes; antennae yellow, the inner sides of first 2 rings of third joint glossy reddish brown; arista whitish; eyes with 4 vertical dark stripes, one on center, deep violaceous blue, extends from upper margin to a point one fifth distant from lower margin, the others (purple) being a slender one along

anterior margin, a broad one extending from lower margin almost to upper margin between the former and the blue central stripe, and a rather broad one along posterior margin. Thorax glossy black, the disc very densely punctate, so that it appears less glossy than the sides; center of disc with a narrow line of silvery pile which extends posteriorly to the diagonal median sutures, the latter with similar silvery pile; sides of mesonotum with silvery pile which is arranged in short irregular stripe-like groups anteriorly, and rather evenly on the entire surface posteriorly; scutellum without silvery pile. Abdomen slightly shining, the surface with piliferous punctures, the hairs slender and rather sparsely and regularly arranged. Legs yellowish white, coxae, trochanters, and femora except their extreme apices, shining black. Wings hyaline, veins pale yellow. Halteres brown, knobs white.

Frons about one fourth the width of head, distance from upper extremity of lateral silvery stripe to anterior ocellus greater than its width at former point; antennae larger than in *punctifer*, third joint higher than long; arista slender, hair-like; antennae inserted below middle of eye, in profile. Scutellum more elongate and less abruptly humped than in *punctifer*. Abdomen differing from that of *punctifer* in the absence of the punctiform groups of silvery pile.

*Male*.—Three male specimens which I have reared differ from the female in having the eyes much closer above, the distance between them not exceeding one tenth the width of head, the antennae smaller and with the third joint conspicuously browned apically, and the eye with only 2 vertical purple stripes—one along anterior margin and the other just proximad of middle, the latter not extending to lower margin. In other respects the sexes agree very closely.

Length, 4 mm.

Type from Savoy, Ill., May 4, 1916, larva under loose bark of apple-tree; imago emerged June 17, 1916. Paratypes from Urbana, Ill., October 21, 1916, larvae under bark of felled elm-tree; imagines emerged December 29, 1916 and January 5, 1917.

I have pleasure in dedicating this species to Mr. Samuel Henshaw, of the Cambridge (Mass.) Museum of Zoology, who kindly submitted the material in that collection for examination when I wrote the paper containing the description of *punctifer*.

There is a specimen of *henshawi* in the Cambridge collection about the sex and identity of which I had some doubt when I examined it. It agrees in every respect with the female now before me.

It seems worth mentioning that while the eyes of both of the above species have vertical color-stripes, *Pachygaster pulcher* has 4

slender horizontal stripes on center, and *Neopachygaster maculicornis* has the upper half of eye, except the narrow posterior margin, purple, the remainder being yellowish.

### ZABRACHIA Coquillett

There is only one species of this genus recorded for North America.

#### GENERIC CHARACTERS

*Larva and Puparium*.—Similar in general appearance to that of *Eupachygaster henshawi*, differing as stated in key to genera.

### ZABRACHIA POLITA Coquillett

*Zabracchia polita*, Coquillett, Bull. 47, N. Y. State Mus., p. 585. (1901)

*Larva and Puparium*.—Length, 3.5–4.5 mm. Dark reddish brown.

Head as in *Eupachygaster*, the bristles longer than in *Neopachygaster*. Arrangement of bristles on body as in the other genera of the Pachygasterinae, but their relative lengths different. The large lateral abdominal bristle in *Zabracchia* is not nearly as long as width of abdomen, while in *Eupachygaster* it is quite as long as the segment which bears it. The other distinctions are indicated in the key to genera.

I have ascertained the above facts from an examination of a specimen sent me by C. W. Johnson, from Massachusetts.

### Subfamily XYLOMYIINAE\*

Williston places the genus *Xylomyia* in his subfamily Arthroceratinæ, along with the genera *Glutops* and *Arthrocera*. His note on page 387 of his Manual would appear to indicate that he considered *Misgomyia* as belonging to the same subfamily. None of the three genera which he includes with *Xylomyia* are known to me. If they belong to the same subfamily as *Xylomyia* the name of the subfamily should be Xylomyiinae, unless one accepts *Solva* Walker as a prior name for the genus *Xylomyia*.

### XYLOMYIA Rondani

I have seen the larva of but one species of this genus. It agrees generally with that of *Xylomyia maculata* Meigen as figured by

\*I have retained the name *Xylomyia* here though the evidence that *Solva* Walker has priority is very strong.

Verrall\*, but differs noticeably in having two hairs instead of six on the dorsum of the thoracic and abdominal segments. It is quite probable that *pallipes* is not congeneric with the other species, good characters existing in larvae and pupae which may be used for their separation.

When emerging the imago withdraws the pupal skin either largely or entirely from the puparium. No other genus of Stratiomyiidae known to me does this. The pupa closely resembles that of Xylophagidae.

#### GENERIC CHARACTERS

*Larva*.—Head large, posteriorly retracted within prothorax; antennae sessile; maxillae with slender transverse ridges. Thorax and abdomen with a few strong hairs on each segment. Prothoracic spiracles large. Anal spiracles separated, situated in a terminal chamber the margins of which protrude lip-like.

I give a synopsis of the imagines of the North American species of *Xylomyia* as the only available ready means of identifying them. The key presented may prove useful to students and save valuable time otherwise required to look up isolated descriptions.

#### KEY TO SPECIES

1. Hind femora spinose beneath. .... *pallipes*.
- Hind femora unarmed. .... 2
2. Coxae black. .... *parens*.
- Coxae in large part yellow. .... 3
3. Thorax with 2 well-defined yellow vittae on disc. .... *americana*.
- Thorax without well-defined vittae. .... 4
4. Hind femora entirely black. .... *aterrima*, ♀.
- Hind femora wholly or largely yellow. .... 5
5. Pleurae entirely black; hind femora reddish yellow. .... *pallidifemur*, ♀.
- Pleurae partly yellow. .... 6
6. Halteres yellow with a brown spot at base of knobs; antennae black. .... *aterrima*, ♂.
- Halteres yellow; antennae reddish on inner side. .... 7
7. Hind coxae blackened in front; hind femora reddish yellow; eyes separated by less than one sixth the head-width; furcation of fourth and fifth branches of radius distinctly distad of a line drawn from apex of third branch of that vein to point of furcation of first and second branches of media. .... *pallidifemur*, ♂.

\*British Flies, Vol. 5, p. 36. (1909)

— Hind coxae yellow; hind femora darkened on apieal third; eyes separated by more than one fifth the head-width; fureation of fourth and fifth branches of radius distinctly proximad of, or in line with, a line drawn from apex of that vein to point of fureation of first and second branches of media. . . . . *tenthredinoides*.

**XYLOMYIA PALLIPES Loew**

*Subula pallipes* Loew, Berl. Ent. Zeitsehr., 1863, p. 6.

*Larva*.—Length, 7–9 mm. Dark brown, head and thoracic segments yellowish, the latter darkened on sides and posteriorly.

Protruded portion of head slightly longer than prothorax, the dorsal surface with several strong hairs (Pl. XLVIII, Fig. 15), labrum conically produced, the apex very sharp (Pl. XLVIII, Fig. 4); mandibles recurved, slightly dentate; maxillae prominent, their ventral surfaces with numerous narrow transverse ridges, palpi inconspicuous (Pl. XLIX, Fig. 7); labial plate as in Figure 10, Plate XLIX; antennae sessile; eyes distinct but not protruded; ventral surface of head with a long hair on each side in transverse line with the eyes. Surfaces of thoracic and abdominal segments finely shagreened excepting a large irregular area on dorsum of prothorax, a narrow transverse area on ventral surface of same segment, a pair of narrow transverse plates on dorsum of metathorax, and the tubercles on the various segments. Prothoracic spiracle with 3 openings (Pl. XLVIII, Fig. 9). Abdominal segments 2–7 each with a transverse series of small round warts near anterior margin on dorsum; eighth segment with 7 rather large warts in an irregular (2, 3, 2) transverse series proximad of median line, posterior lateral angle with 2 small warts; all ventral segments with a closely placed series of small warts on their anterior margins; anal opening slightly T-shaped, the margins toothed; spiracles distinctly separated, situated within an apical chamber whose margins protrude lip-like from apex of eleventh segment and appear like an additional segment; thoracic and abdominal segments, except the apical one, each with 6 hairs, one on each lateral margin and one on each side on venter and dorsum; apical segment as in Figure 14, Plate XLVIII.

This description was drawn from larvae obtained by me October 21, 1916, under the bark of trees which had been felled in the spring of the same year. The bark was beginning to loosen, and larvae of *Euxesta*, *Lonchaca*, and *Heteromerengia* were abundant under it. The Xylomyia larvae were found to be predaceous, feeding indiscriminately upon the other larvae. They have a peculiar habit of raising up the thoracic segments when disturbed, but are very sluggish.

This species is undoubtedly the commonest of the genus. It was originally described from Illinois and Wisconsin, and has since been recorded from Montana, southern California, Colorado, New Jersey, and "the Atlantic States". It occurs commonly on tree-trunks in June, July, and August throughout Illinois.

Townsend has described the puparium and pupa, and given a brief account of the habits of the species\*.

**XYLOMYIA PARENS** Williston

*Subula parens* Williston, Can. Ent., Vol. 17, 1885, p. 122.

Described from Washington State and not subsequently recorded.

**XYLOMYIA AMERICANA** Wiedemann

*Xylophagus americanus* Wiedemann, Dipt. Exot., Vol. 1, p. 51. (1821)

This species was originally described from "North America." It has since been recorded from Mexico, Illinois, and Pennsylvania. I have before me an example from Urbana, Ill., taken June 17, 1916; on a window, and one bearing the label N. Ill., which, I am informed, stands for Algonquin or vicinity.

**XYLOMYIA ATERRIMA** Johnson

*Xylomyia aterrima* Johnson, Ent. News, Vol. 14, 1903, p. 24.

This species was originally described from examples from northern Illinois and Fredonia, N. H.

It is unrepresented in our Laboratory collection.

**XYLOMYIA PALLIDIFEMUR** n. sp.

*Male*.—Head brownish black; 2 spots above bases of antennae and the face whitish pilose; antennae blackish brown, reddish on inner side of basal half; proboscis and palpi yellow. Thorax reddish brown, blackened behind humeri, above bases of wings, in front of scutellum, on a vertical area on anterior half of mesopleura and sternopleura, on the greater portion of the hypopleura, and at the center of postnotum; yellow marks cover the whole of humeri, both sides of the transverse suture narrowly, all of the pleurae except the black portions, and the center of scutellum. Abdomen reddish, the dorsum more or less infuscated. Legs pale yellow, hind pair more reddish yellow; anterior

\*Ent. News, Vol. 4, 1893, p. 163.

surface of hind coxae and apical 4 joints of hind tarsi fuscous. Wings clear, veins pale brown. Halteres reddish yellow.

Eyes separated by about one seventh the head-width; antenna about  $1\frac{1}{2}$  times as long as height of head, the flagellum slender, apical joint as long as preceding 2 together. Thorax and abdomen with short hairs. Wing venation similar to that of *americana*, as indicated in key.

*Female*.—Differs from the male in having the pleurae entirely black, and the apex of abdomen deep black.

The wing venation differs slightly from that of the male, the furcation of radius being but little distad of a line drawn from apex of third branch of radius to point of furcation of first and second branches of media.

Length: male, 11 mm.; female, 13 mm.

Type locality, Urbana, Ill.; 1 male, June 17, 1890; 2 females, June 1 and 2, 1890,—(C. A. Hart).

### XYLOMYIA TENTHREDINOIDES Van der Wulp

*Subula tenthredinoides* Van der Wulp, Tijdschr. v. Ent., Vol. 10, 1867, p. 132.

This species was originally described from specimens obtained from Wisconsin. It has since been recorded from Illinois and Pennsylvania. There are specimens in our collection here from Algonquin, Urbana, St. Joseph, Augerville, and Grand Tower,—Illinois, all taken in June of various years.

## STRATIOMYIID LARVAE OF UNCERTAIN GENERIC LOCATION

### GENUS INCERTUS I

*Larva* (Pl. XLIX, Fig. 11).—Length, 7 mm. Pale grayish brown.

Head rather long, tapered anteriorly; maxillae armed with numerous curved hairs apically; antennae long and slender, apical joint short and stout. Body broad, the surface covered with fine hairs (not shown in figure except along lateral margin); each segment with very weak bristles arranged in transverse series much as in Pachygasterinae. Lateral margins of each abdominal segment except the apical one divided into two lobes, the anterior one slender and acute, the posterior one much broader and obtuse; lateral abdominal spiracles rudimentary; a number of short bristles surrounding bases of the larger

ones composing the transverse series on abdominal segments; apical segment with a conspicuous fringe of long soft hairs; respiratory chamber preapical, rather wide centrally.

Described from a specimen obtained in woods at Urbana, Ill., April 30, 1887 (C. M. Weed).

This specimen differs so strikingly from any previously described stratiomyiid that I do not feel justified in suggesting its location in the family.

#### GENUS INCERTUS 2

*Larva*.—Length, 12 mm. Yellowish brown.

Head very similar to that of *Hermetia*, the hairs on anterior portion and the antennae short. Body of a more uniform width than in *Hermetia*, not broadened apically. Thoracic segments with 2 long and 2 or 4 short bristles in a nearly straight transverse row on dorsum, and a group of 2 to 4 bristles on a common base on each side of venter. Abdominal segments except apical one each with 4 rather weak bristles close to posterior margin and 2 very long and strong ones near anterior margin; as shown in Figure 8, Plate XLIX; ventrally, the series of 6 bristles nearly straight on each segment and the median two weaker than the others; lateral bristles and dorsal armature of apical segment as in above figure; venter of apical segment with 4 bristles on a distinct ridge proximad of anterior extremity of anal opening, the latter fringed with short upright scales; a series of 4 long bristles distad of posterior extremity of anal opening.

Described from a specimen obtained by C. A. Hart in the nest of a cactus rat at Brownsville, Texas, December 1, 1910.

#### GENUS INCERTUS 3

*Larva*.—Length, 4.5 mm. Yellowish testaceous.

Head long, tapering anteriorly; antennae short; maxillae fringed anteriorly and rather conspicuous; most of the surface bristles tapering, the one above posterior margin of eye slightly clavate. Body parallel-sided, the surface shagreened and covered with minute scales, each segmental incision marked by a double series of small black dots, and several similar dots on each segment laterally. First thoracic segment with the usual 2 transverse series of bristles on dorsum, the others with a single series of 6 each which are, like those of the abdomen, distinctly clavate; ventral surface of each segment with 6 slightly clavate bristles in almost straight transverse series. Abdominal segments with a single clavate bristle on each lateral margin, 6

such bristles on dorsum, and 6 on venter, the latter series not straight and the median two much more widely separated than the others, the outer one on each side considerably proximad of the others and less noticeably clavate; apical segment with dorsal armature as in Figure 1, Plate XLIX; the anal opening unfringed; respiratory chamber small, the opening oval.

The foregoing description was made from a specimen submitted along with a larva of *Microchrysa polita*, and under the same name, by J. A. Hyslop, from Hagerstown, Md. The label indicates that the larvae were feeding upon an arctiid pupa.

#### PRINCIPAL PAPERS ON NORTH AMERICAN STRATIOMYIIDAE

Hart, C. A.

'95. On the entomology of the Illinois River and adjacent waters. Bull. Ill. State Lab. Nat. Hist., Art. VI, 4: 247-266.

Johnson, C. W.

'95. Review of the Stratiomyiae and Odontomyiae of North America. Trans. Am. Ent. Soc., 22: 227-278.

Malloch, J. R.

'15. A revision of the North American Pachygasterinae with unspined scutellum. Ann. Ent. Soc. Amer., 8: 305-320.

Melander, A. L.

'03. A review of the North American species of *Nemotelus*. Psyche, 10: 171-183.

#### Family XYLOPHAGIDAE

There can be no doubt that the species herein included should constitute a distinct family. The larvae differ from those of Stratiomyidae and Leptidae in many respects, and the pupae also are sufficiently distinct to entitle them to rank in a distinct family.

Without a knowledge of the immature stages of *Rhacicerus* and *Arthropeas* I do not think it advisable to give a definite opinion on their family status. Brauer in 1882\* placed them in Xylophagidae on characters possessed by the imagines. By the use of the same characters he placed *Xylomyia* (*Subula*) also in this family, but subsequently, in the same publication (1883), he transferred it to Stratiomyidae because of the characters of the early stages. It will probably be best to retain the two genera in question in Xylophagidae pending further knowledge as to their early stages. Brues and

\*Denkschr. k. Akad. Wissensch. Wien, math.-naturw. Cl., Vol. 44, p. 86.

Melander have placed *Arthropeas* in Stratiomyidae and *Rhacicerus* in Xylophagidae in their recent book\*, using the adult characters as their criteria.

#### FAMILY CHARACTERS

*Larva*.—Head not retractile, the exposed portion in the form of a chitinized cone, from a small apical opening in which the mandibulate portions are extruded; several strong hairs on dorsum. Dorsum of some of the thoracic segments chitinized entirely or in part, usually in the form of 3 plates; prothoracic spiracle large. Abdominal segments with locomotor spines in transverse series; apical segment obliquely truncated, the apex heavily chitinized, and with 2 backwardly projecting processes on lower margin; spiracles large, rounded, widely separated, situated above middle of the chitinized plate. Thoracic and abdominal segments each with a number of strong hairs.

*Pupa*.—Head without thorns except sometimes one on base of each antennal sheath, the latter separated from surface of head, elongate, directed almost straight laterad, their apical portions rounded in cross-section and distinctly annulated. Thorax with marginal series of punctures along the sutures; wings extending to apex of first abdominal segment; apices of hind tarsi extending to or very slightly beyond apices of wings. Abdominal armature increasing in strength from second segment to apical one, almost absent on basal; apical segment ending in a bifid tubercle.

*Imago*.—The species are very closely allied to those of Leptidae, but may be readily separated from the latter by the structure of the antennae, as indicated in the synoptic key to families of Brachycera.

#### LARVAL AND IMAGINAL HABITS

The larvae as far as known live under bark or in earth and feed upon larvae of other insects. The imagines are found generally in woods, and as far as I have observed feed upon nectar of flowers and sap or other liquid matter.

#### XYLOPHAGUS Meigen

##### KEYS TO SPECIES

###### LARVAE

1. First and second thoracic segments chitinized dorsally.....*lugens*.
- First, second, and a large portion of third thoracic segments chitinized dorsally.....*abdominalis*.

\*Key to the Families of North American Insects, p. 64. (1915)

## PUPAE

1. Antennal sheath with a thorn at base.....*lugens*.
- Antennal sheath without a thorn at base.....*abdominalis*.

## IMAGINES

1. Legs entirely black, at most the apices of the coxae yellow; basal antennal joint much elongated (Mass.).....*longicornis* Loew.
- Legs with a considerable proportion or all of femora and tibiae reddish or yellowish.....2
2. Abdomen largely reddish.....3
- Abdomen black or blackish brown.....4
3. Abdomen ferruginous, sutures and lateral margins of segments black; legs tawny, tibiae and tarsi brownish and darker than the femora (Martin's Falls and Montreal, Canada) ..*fasciatus* Walker.
- Abdomen black, broadly reddish on disc of segments 2 to 5; legs reddish, apical 2 joints of all tarsi blackened (Texas, N. J.).....*abdominalis* Loew.
4. Hind legs almost entirely black, only the extreme bases of femora and tibiae and the larger basal portion of metatarsi whitish yellow (Ill., N. Y., N. J., Pa., N. H.).....*lugens* Loew, ♀.
- Hind legs with a greater proportion of their surfaces yellowish or whitish.....5
5. Legs reddish or tawny, only apices of tarsi blackened.....6
- Legs with some portion of femora or tibiae blackened or browned..7
6. Antennae not longer than head, entirely black; proboscis ("mouth", Walker) yellow (N. Y.).....*reflectens* Walker.
- Antennae longer than head, tip of first joint and second reddish brown; proboscis black (Wash. State).....*decorus* Williston.
7. Legs reddish, apical third of hind tibiae and apices of tarsi blackened (Mass.; Montreal, Can.; White Mts., N. H.; N. J.; Axtion, N. Y.).....(persequus Walker) *rufipes* Loew.
- Legs yellowish testaceous or pale yellow, femora blackened or distinctly browned at apices.....8
8. Legs yellowish testaceous, all femora broadly sulfurous apically, tips of fore and mid tibiae, hind tibiae except bases, and all tarsi except bases of metatarsi blackened.....*lugens* Loew, ♂.
- Legs pale yellow, apices of all femora, tips of hind tibiae and of all tarsi light brown (Wash., Oregon).....*gracilis* Williston.

As this key is largely compiled from descriptions it will be necessary to use it with considerable caution. I am not entirely convinced of the specific distinction of several of the species, but without examining the types it is not possible to find characters for the separation other than those given here. Say's species *triangularis* is not, I am convinced, a *Xylophagus*.

## XYLOPHAGUS LUGENS Loew

*Xylophagus lugens* Loew, Berl. Ent. Zeitsehr., 1863, p. 6.

*Larva* (Pl. L, Fig. 5).—Length, 15–20 mm. White, slightly shining, chitinized portions castaneous, glossy. Head long and pointed, with a few surface hairs arranged as in Figure 12; anterior opening very small, mandibles normally slightly exserted; the pair of chitinized rods which protrude into the first thoracic segment usually visible through the semitransparent membrane at back of head. First and second thoracic segments heavily chitinized on dorsum and with narrow pale unchitinized longitudinal lines as shown in Figure 5; spiracle large, situated beyond middle of first segment; armature as shown in Figure 5; last thoracic segment not chitinized; ventral surface of first segment with a brown chitinized patch on each side which is dilated anteriorly and tapers to a point posteriorly; occasionally the median space between these patches anteriorly almost covered with small brown spots; second and third segments without chitinized areas; each of the three segments with a hair on each side near lateral margin slightly beyond middle. Dorsum of abdomen with a transverse band of locomotor spines on anterior margins of segments 1–6 which does not extend to lateral margin; each suture, between both thoracic and abdominal segments, marked by a line of small punctiform brown chitinized areas; laterad, except between segments 7 and 8, this line is duplicated, the two lines enclosing a vertical elongate-oval area which ceases at margin of ventral surface; seventh segment with 4–5 poorly developed spines on each side anteriorly, some distance from median line; eighth segment usually with a few round brown spots on anterior portion about midway from median line to lateral margin, and with a larger chitinized spot on each side of disc near posterior margin; apical segment very heavily chitinized, ending in 2 divergent, slightly upwardly curved processes; spiracles large, round, slightly elevated; dorsum of abdomen, except that of apical segment, without hairs; lateral area of segments 1–7 each with 4 strong hairs arranged in a vertical series on middle of segments, the upper pair more widely separated from the second than the other pairs are from each other; armature of apical segment as in Figure 5; ventral surface different from dorsal in having the locomotor spines present on segments 1–7 and in having a large brown mark surrounding the anal opening.

*Pupa* (Pl. L, Fig. 1).—Length 10–16 mm. Brownish testaceous, slightly shining, turning almost entirely black just before emergence of adult.

Antennal sheaths distinctly annulated, the anterior basal surface of each with a stout thorn (Pl. L, Fig. 6); entire aspect of head and mouth parts as in figure just mentioned; dorsal surface of head-capsule with 3 small punctiform depressions on ocellar region and on each side a single hair; suture between cephalic and thoracic segments deep, the posterior margin of the former with short longitudinal impressed lines. Thoracic spiracle much elevated, in the form of a short stout tubercle, the apical opening small, somewhat 8-shaped; prothorax with a transverse discal, linear series of small closely placed round depressions; mesothorax with 2 faintly indicated sutures and 2 rather large poorly defined depressions, one behind the other, above wing-base; wings without discal protuberances, their apices rather widely separated, extending distinctly beyond apices of fore tarsi; apices of mid and hind tarsi curved towards median line, the latter extending little beyond apices of wing. Abdominal spiracles similar in form to those of thorax but not so much elevated; first dorsal abdominal segment with 4 weak, widely separated hairs on disc near posterior margin, the median pair much closer to each other than they are to the lateral hairs; lateral areas with 4-6 hairs; segments 2-7 each with a transverse post-median series of closely placed hairs which become progressively slightly stronger from 1 to 7; eighth segment with 4-5 spines on each side of disc in a transverse series; postspiracular area of first segment with 7-8 strong bristles; ventral segments similar in armature to dorsal; apical segment of female as in Figure 2, Plate L.

Larvae of this species were common under bark of a felled elm at White Heath, Ill., March 12, 1916. Several specimens pupated from 3 to 5 days after being brought to the laboratory, and the first imago emerged on March 22, others appearing on the 25th and 26th.

When collecting the larvae I also captured several larvae of *Saperda tridentata*, and others of *Meracantha contracta* (Coleoptera), which I brought in to ascertain whether the xylophagid would eat either of them. One of the *Meracantha* larvae was eaten, the entire contents being extracted through a hole made in the skin; but the *Saperda* was not attacked. It is very probable that the food of the xylophagid does not consist wholly of the larvae of *Meracantha* as this species was rarely met with in company with the larvae of the fly, and probably *Saperda* is also eaten.

The logs in which I found the larvae were second-year lumber on which the bark was not very loose. When the borings of other insects have thoroughly loosened the bark, conditions are apparently not suitable for the larvae, as none were found in such logs.

The larva and pupa of this species have previously been described by Johnson\* and by Felt†, the latter donating an imago and pupal exuvium of *lugens* to the collection of the Laboratory.

Originally described from Illinois, *lugens* has subsequently been recorded from Riverton, N. J.; and from Pennsylvania, New Hampshire, and New York.

#### XYLOPHAGUS ABDOMINALIS Loew

*Xylophagus abdominalis* Loew, Berl. Ent. Zeitschr., 1869, p. 163.

*Larva*.—Length, 16–21 mm. Differs from larva of *lugens* as follows: the longitudinal pale streak on second thoracic segment simple, not Y-shaped; third thoracic segment with conspicuous, brown, chitinized dorsal patches (Pl. L, Figs. 10, 11); thoracic and abdominal hairs much weaker and paler.

*Pupa*.—Length, 14 mm. Differs from pupa of *lugens* as follows: antennal sheath without basal thorn (Pl. L, Fig. 7); ventral aspect of head and mouth-parts as in same figure; dorsum of head with about 12 long hairs on each side of disc; thoracic spiracles less elevated; apical segment of abdomen with the bifid process shorter and stouter.

The examples used for the above descriptions were supplied by C. W. Johnson and were found under the bark of a decaying pine-tree at Riverton, N. J.

The species was originally described from Texas, and has not been recorded from any locality except Riverton as far as I am aware.

#### Family COENOMYIIDAE

Only two genera and three species are considered as belonging to this family in North America, but if the catalogues are to be credited one of these, *Coenomyia pallida* Say, has been described by various authors under sixteen or more different specific names. In Aldrich's "Catalogue of North American Diptera" the name accepted for our species is *ferruginea* Scopoli. I have some doubt about the identity of our species with that of Europe, as Beling's description of the larva of *ferruginea* does not fit that before me, and I use Say's name for the species in this paper. The differences are noted on a subsequent page.

\*Ent. News, Vol. 14, 1903, p. 23.

†Bull. 155, N. Y. State Mus., p. 121. (1912)

I do not know the larvae of *Arthropeas*, which may not conform to the characters here given for the family.

#### FAMILY CHARACTERS

*Larva*.—In general appearance similar to Xylophagidae. Head rather large, the exposed portion in the form of a strongly chitinized cone, from the small apical portion of which are protruded the mandibulate parts. Thoracic segments each with a pair of round oval chitinized plates under the skin. Apical abdominal segment obliquely truncated, the lower posterior margin with a pair of projecting processes; posterior spiracles widely separated, situated above middle of apical plate, anterior pair on sides of first thoracic segment.

*Pupa*.—Head without projecting thorns; antennal sheaths elevated, the annulation indistinct. Abdomen with comparatively weak armature, which becomes stronger apically; postspiracular areas each with 2 bristles; apical segment with a fan-shaped armature of 5-6 bristles on each side; apical protuberances small.

*Imago*.—Very large, robust species, of a variable brownish or testaceous color. Distinguishable from the Leptidae, in which family it has been placed by some authors, by the elongated and annulated third antennal joint. The males of both genera may be separated from Xylophagidae by the contiguous eyes; both sexes of *Coenomyia*, by the spines on scutellum; and both genera, by the characters given in key to imagines of Brachycera.

#### HABITS OF LARVAE

The larva of *Coenomyia pallida* is usually found in the ground, those that I have before me being obtained in fields some distance from any timber. They are, however, sometimes found in decaying wood. They are predaceous upon insect larvae. A specimen found in a field near Chicago fed upon white-grubs. The larvae are very sluggish, moving very slowly through the earth, and are almost incapable of making progress upon a smooth surface. I know of no parasites of the larvae.

#### HABITS OF IMAGINES

*Coenomyia pallida* is usually found near streams and more particularly among undergrowth or trees, and is rather sluggish. The food consists of fluid matter or nectar of flowers.

## COENOMYIA PALLIDA Say

*Coenomyia pallida* Say, Keating's Narrative of an Expedition to the Source of the St. Peter's River, Appendix to Vol. 2, p. 339. (1824)

*Larva*.—Length, 38–45 mm. White; head and chitinized plate on apical abdominal segment castaneous.

Body cylindrical, slightly tapered anteriorly. Head large, conical, permanently protruded, the movable portions enclosed except at apex; retracted portion consisting of an areuate dorsal plate and 4 slender chitinized rods (Pl. L, Figs. 3 and 4). Thoracic segments not chitinized externally, but each with a pair of chitinized internal plates which decrease in size from prothorax to metathorax, the anterior pair transversely oval and occupying the greater portion of the ventral surface; ventral hairs of moderate length. Apical abdominal segment with a heavily chitinized plate, the upper margin of which is proximad of the lower, giving the segment the appearance of being obliquely truncated; spiracles round, situated above middle of apical plate; lower margin of plate with 2 short, stout processes (Fig. 9).

*Pupa*.—Length, 30–35 mm. Dark brown, subopaque.

Head, viewed from in front, as in Figure 8, Plate L, the antennal sheath elevated, with minute thorns, the annulation indistinct. Wings short, extending to apex of first abdominal segment; apices of hind tarsi scarcely extending beyond apices of wings, and closely fused to the latter; thoracic spiracles sessile. Abdominal spiracles of moderate size, their breadth less than their height; basal dorsal abdominal segment with 2 bristles on each side beyond middle; second and following segments up to and including seventh with a complete transverse series of short spines and 6 or more long bristles, the armature increasing in strength up to seventh segment; eighth segment with a group of 2–4 bristles on each side of apex above, a lateral vertical series of 5 longer spines on a raised base, and a pair of stout protuberances, on a single base, on ventral surface at apex (Fig. 12); postspiracular area of each segment with 2 strong bristles; ventral segments with armature similar to that of dorsal but noticeably stronger; apical segment as in Figure 13.

The above descriptions were made from specimens obtained in Illinois, the data being as follows: Du Quoin, August 13, 1908, turned up by plow (L. M. Smith); larval exuvium and pupa, Chicago, August, 1913 (D. K. McMillan); pupal exuvia, Havana, June 15, 1894 and Grafton, August 26, 1905.

The larva obtained by Mr. McMillan fed upon white-grubs in confinement, and as it was taken in a field where these were common

it is very probable that they constituted its food there. The specimen taken by Smith was taken in company with larvae of Asilidae and probably fed also upon white-grubs, which are the principal food of the asilids. The pupal exuvia listed were found protruding from rotten tree-stumps.

In addition to the above we have imagines in our collection here from Algonquin, Chicago, and Fourth Lake—all in Illinois.

The larvae of the European species *ferruginea* Scopoli, is described as having the second thoracic segment with 5 chitinized longitudinal dorsal bands. I can not find these bands on any larvae available to me, and consider it possible that our species may not be the same as the European one.

### Family ACANTHOMERIDAE

This family is found only in Central and South America, and is considered by some authors as doubtfully separate from Stratiomyidae.

The larva of one species has been figured by Brauer\*, and its general appearance and the structure of the cephalic, thoracic, and apical abdominal segments ally it closely with Coenomyiidae.

### Superfamily Tabanoidea

I have placed in this superfamily the families Tabanidae and Leptidae.

#### SUPERFAMILY CHARACTERS

*Larva*.—Head small, wholly or partly retracted, permanently retracted portion with an arcuate dorsal plate over the longitudinal rods; mandibles strong, hook-like, curved downward; maxillae well developed, wholly or largely membranous, the palpi well developed; antennae distinct, pedunculate. Body cylindrical, with or without pseudopods; lateral abdominal spiracles absent in Tabanidae, small but no lateral spiracles distinguishable in Leptidae; apical spiracles in a vertical fissure in Tabanidae, exposed and separated in Leptidae.

*Pupa*.—Head without strong cutting armature; antennae with or without distinct annuli. Thoracic respiratory organs sessile. Wings and legs closely fused to each other and to thorax; fore tarsi overlying mid pair, the latter overlying hind pair, the pairs successively longer, hind pair not extending beyond apices of wings. Abdomen

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\*Denschr. k. Akad. Wissensch. Wien, math.-naturw. Cl., Vol. 47. (1883)

with seven pairs of lateral spiracles; segments armed with transverse series of slender bristles which become progressively stronger from base to apex of abdomen.

*Imago*.—See descriptions under families, and synopsis in key to imagines of Brachycera.

### Family TABANIDAE

#### FAMILY CHARACTERS

*Larva*.—Head small, retractile, the parts as in Figure 1, Plate LII. Body circular in transverse section, elongate, tapering at both ends, and with encircling locomotor swellings at the segmental sutures in all genera except *Goniops*. In the latter the cephalic and thoracic segments are very much tapered and considerably longer than the abdominal segments; the abdomen is stout and obtusely rounded apically, the locomotor swellings being on the anterior third of each of the well-differentiated segments. The posterior respiratory organs are close together and situated in a vertical cleft.

*Pupa*.—Head without projecting thorns. Thoracic respiratory organs sessile, connected subcutaneously with a large cavity on each side of median line close to anterior margin of prothorax (Pl. LII, Figs. 2, 3). Wings and legs rather short. Abdominal armature consisting of 1, or 2 closely contiguous, series of bristles on each dorsal segment except first, and a weaker transverse series on ventral segments; apical segment ending in 6 stout processes which are more or less radiate and pointed (Pl. LI, Figs. 4, 5).

*Imago*.—Distinguished from other Brachycera by the peculiar shape of the third antennal joint, the chitinized portions of proboscis, very robust body, and the wing venation.

#### HABITS OF LARVAE

Aquatic or semiaquatic, found rarely among decaying leaves or in low and somewhat marshy spots in fields. As far as known, the larvae are predaceous, the food of the species occurring in rivers being mostly tipulid and other larvae which burrow in the soft banks of the rivers or occur in the river bottom or in drift.

Some species are kept in check by the destruction of their eggs by hymenopterous parasites.

#### HABITS OF IMAGINES

The adults of this family are familiarly known as gadflies, horseflies, clegs, breeze-flies, etc. They rank with the worst of the

biting pests that affect cattle. The species of *Tabanus* attack cattle and other farm animals almost exclusively, but *Chrysops* is a persistent pest to human beings also, especially near rivers, lakes, or large pools. At least one African species of *Chrysops* is responsible for the conveyance of a disease affecting man, which in some respects resembles filariasis—a disease conveyed by mosquitoes.

Some interesting data upon the egg-laying and other habits of this family are contained in the papers listed at the end of the text on the family.

#### KEY TO GENERA

##### LARVAE

1. Body club-shaped, the thoracic segments slender, the abdominal segments robust.....*Goniops* (p. 356).
- Body tapered anteriorly and posteriorly, not club-shaped.....2
2. Apical antennal joint much longer than the preceding joint; dorsum of thoracic segments as strongly striated as those of abdomen.....*Chrysops* (p. 357).
- Apical antennal joint not longer than the preceding one; dorsum of thoracic segments either smooth or not as strongly striated as those of abdomen.....*Tabanus* (p. 358).

##### PUPAE

1. One spine on each side of median line on dorsum of each abdominal segment much stronger than the others in the series.....*Goniops*.
- The spines of each series either of an almost uniform strength, or at least no two spines conspicuously stronger than the others..2
2. Antennae projecting beyond lateral margin of head; abdominal spines uniform in length; head with 4 bristles on dorsum (Pl. LII, Fig. 5).....*Chrysops*.
- Antennae not projecting beyond lateral margin of head; abdominal spines long and short in each series; head with 2 bristles on dorsum (Pl. LII, Fig. 4).....*Tabanus*.

#### GONIOPS Aldrich

##### GENERIC CHARACTERS

*Larva*.—Mandibles stout, slightly curved, apically truncated; antennae elongate, 3-jointed, basal joint stout, tapering apically, about twice as long as apical 2 combined; apical joint much shorter than preapical; maxillary palpi 2-jointed, the apical joint slender and distinctly shorter than the basal. Thoracic segments very distinctly tapered anteriorly, abdomen stout, roughly oval in outline, the whole

body appearing pyriform or slightly club-shaped; abdominal segments with rather irregularly arranged transverse series of locomotor tubercles; spiracular chamber in the form of a vertical slit.

*Pupa*.—Head without projecting thorns; antennal sheath short, curved downward. Prothorax about one third as long as mesothorax; wings short, extending to apex of first ventral abdominal segment; apices of hind tarsi slightly surpassing apices of wings. Armature of dorsal abdominal segments consisting of stout thorns in a transverse series, 2 of which, near middle of segments 2 to 7, are much stronger than the others; laterad the series are discontinued some distance from margins; apical segment with 3 strong thorns on each side, between which are several weaker protuberances.

*Imago*.—The only species of the genus (*chrysocoma* Osten Sacken) may be distinguished from other Tabanidae by the following characters: third antennal joint consisting of 8 segments, the basal one only slightly longer than the next; fourth posterior cell open; eyes of female acutely angled above; hind tibiae with apical spurs.

#### HABITS OF LARVAE

The eggs are usually deposited on the under side of leaves of various plants, and when the larvae hatch they drop to the ground, living afterwards among the decaying leaves and other vegetable debris. They are very probably predaceous like other Tabanidae.

The egg-masses are parasitized by a proctotrypid species.

#### HABITS OF IMAGO

The female while ovipositing has the habit—which is very rare among Diptera—of brooding her eggs. The species is very rare, and so far as I know has never been taken in Illinois.

For details of life-history see the papers by McAtee and by Walton listed at the end of the family discussion.

### CHRYSOPO<sub>S</sub> Meigen

I have before me a number of larvae belonging to different species of this genus, but only one has been definitely associated with the pupal and imaginal stages.

#### GENERIC CHARACTERS

*Larva* (Pl. LI, Fig. 1).—Spindle-shaped, very distinctly tapered towards each extremity. Head small, entirely retractile; antennae

long and rather slender, the apical joint longer than the basal; labrum pointed, armed beneath with some strong short bristles; maxillae stout, their palpi as long as the antennae and stouter, the joints well differentiated; mandibles long and strong, distinctly curved downward and slightly backward. Thorax sometimes with 8 slightly elevated areas that appear somewhat like plates—a broad one on venter, a similar one on dorsum, and 3 narrow ones on each side. Body with close longitudinal striae; pseudopods distinct, arranged in a circular series on anterior margin of each abdominal segment except the apical one; apical segment with the spiracular portion retractile, the spiracles in a vertical cleft.

*Pupa*.—Similar in general appearance to the pupa of *Tabanus* (Pl. LI, Fig. 6), the principal differences between the genera as stated in the key.

#### TABANUS Linné

In point of numbers this genus is the largest of the family, and it also contains the largest species, some of them exceeding an inch in length.

##### GENERIC CHARACTERS

*Larva*.—The larvae of *Tabanus* closely resemble those of *Chrysops* in general structure, being elongate, circular in cross-section tapering at both extremities, and armed, at least on the abdominal segments, with more or less well-defined pseudopod-like tubercles—2 on dorsum and 4 on venter—which usually form an almost complete circle on the segments anteriorly. Head as in Figure 1, Plate LII. The structure of the antennae separates the two genera.

*Pupa* (Pl. LI, Fig. 6).—The antennae are shorter in *Tabanus* than in *Chrysops*, the thoracic spiracles are rather different in structure, being more nearly vertical, and the abdominal armature differs as indicated in the preceding key to genera.

*Imago*.—The hind tibiae differ from those of *Chrysops* in having apical spurs. From other Tabanidae possessing hind tibial spurs the species may be distinguished by the 5-segmented third antennal joint, with its distinct dorsal basal angle, and the absence of a cilia of hairs on the hind tibia.

##### HABITS OF LARVAE

See under family.

##### HABITS OF IMAGINES

The species of this genus are very serious pests of cattle, and cause considerable loss to cattlemen in well-watered areas where they

occur commonly. Some success in destroying the flies has been attained by spreading a film of kerosene on the surface of pools where the insects occur. The flies have a peculiar habit of dipping down to the surface of the water, assumably for the purpose of drinking, and when the oil is present large numbers are destroyed. Various skin lotions, or washes, consisting of lard and sulphur or of carbolic acid in varying strength, have been tried as repellents, but usually with very little success. Even hogs that are regularly washed with various crude-oil preparations to destroy lice are attacked freely by such species as *atratus*.

Some of the larger asilids, or robber-flies, prey upon the adults and succeed in killing even the largest of them.

#### KEYS TO SPECIES

##### LARVAE

1. Body without markings either of color or hairs.....2
- Body either with a series of distinct brown spots or with brown marks .....
2. Body very closely and finely striated, entirely white. *Tabanus* sp. 1.
- Body coarsely striate, abdominal segments each with an indistinct pale annulus on anterior margin.....*costalis*.
3. Abdominal segments with very faint anterior annuli.....*costalis*.
- Abdominal segments either with very well-defined anterior annuli or each segment with a brown spot on each side on extremity of dorsal transverse swelling.....4
4. Brown markings consisting of a small spot on the outer extremity of each dorsal abdominal transverse swelling.....*Tabanus* sp. 2.
- Brown markings in the form of well-defined annuli.....5
5. Lateral raised striated areas of prothorax each about as long as the dorsal one .....
- Lateral raised striated areas of prothorax each about half as long as dorsal one .....
6. Brown stripe between dorsal striated area and upper lateral one dilated posteriorly, causing the former to be parallel-sided on its posterior half (Pl. LI, Fig. 3).....*atratus*.
- Brown stripe between dorsal striated area and upper lateral one tapered, or at least not dilated, posteriorly, the sides of the dorsal area divergent throughout their entire length (Pl. LI, Fig. 2) ..7
7. Lateral striae of prothorax very fine, opaque, those of metathorax much coarser, shining.....*Tabanus* sp. 3.
- Lateral striae of prothorax but little finer than those of mesothorax .....

*stygius* and *nigrescens*.

## PUPAE

1. Dorsal abdominal segments, except first, armed with an irregular transverse series, or 2 such series, of very stout thorns, their bases very much dilated, slightly caudad of which series there are sometimes a few widely separated, much longer spines.....2
- Dorsal abdominal segments, 4 to 6 at least, with 1 or 2 transverse series of short irregular spines the bases of which are not much dilated, and slightly caudad of these is a transverse series of closely placed, very long, slender bristles.....4
2. Seventh dorsal abdominal segment with 10—12 moderately long thorns in a continuous transverse series, slightly cephalad of which is a transverse series of very short stout thorns longitudinally in line with the spaces between the thorns of the posterior series....  
.....*carolinensis* Macquart.
- Seventh dorsal abdominal segment with the posterior transverse series consisting of 2 long, widely separated spines on middle portion, and several, closely placed, on each lateral extremity which are but little caudad of the much shorter thorns of the anterior series.....3
3. The portion of head-capsule between bases of antennae distinctly elevated, flattened, strongly rugose, the lower extremity of the elevation strongly carinate and with a central incision; abdominal armature very strong, having much the appearance dorsally of a single irregular transverse series on each segment.....  
.....*lasiophthalmus* Macquart.
- The portion of head-capsule between bases of antennae slightly elevated, rounded, faintly rugose, and not carinate or divided below; abdominal armature moderately strong, distinctly biserial laterally.....*epistates* Osten Saeken.
4. Small species, 20 mm. or less in length; abdominal spiracles with C-shaped rima.....5
- Larger species, at least 25 mm. in length; abdominal spiracles with very much elongated vertical rima, the upper and lower extremities slightly curved forward.....6
5. Bristles on eighth ventral abdominal segment fused basally, giving them the appearance of an elevated ridge with a serrate edge....  
.....*lineola* Fabricius.
- Bristles on eighth ventral abdominal segment not fused basally....  
.....*costalis* Wiedemann.
6. The long spines on dorsal abdominal segments with a ring beyond middle and their apices black; short spines on median portion of each anterior transverse dorsal series stout and almost uniform in length.....*atratulus* Fabricius.
- The long spines on dorsal abdominal segments either black-tipped or all pale, without a black preapical ring; short spines in anterior dorsal series slender and very uneven.....7

7. A small but distinct tubercle just in front of base of middle leg in addition to and some distance above the one bearing the paired hairs\* ..... *nigrescens* Palisot de Beauvais.  
 — No tubercle present as above ..... *stygius* Say.

In order to keep this paper within reasonable limits I have not drawn up descriptions of the larvae and pupae of this genus, reserving that for a future article in which I hope to cover the family.

Most of the species have already been described by C. A. Hart in his paper "On the Entomology of the Illinois River and Adjacent Waters". My Species 1 is the only larva not included in that paper. It differs from the other larvae before me in being entirely white and without lines or patches of pubescence, as well as in being more robust, and less tapered at the extremities. In general appearance it very closely resembles an asilid larva, the resemblance being accentuated by the small size of the locomotor organs; and it stood as "Asilidae" in our collection. The specimen was obtained at Pulaski, Ill., June 1, 1910, in a pit-cage used in rearing white-grubs. This is a surprising occurrence as most of the species are confined to damp ground or to aquatic surroundings.

The species designated as Species 2 and Species 3 in the key to larvae are Hart's species *a* and *b*.

PRINCIPAL PAPERS DEALING WITH THE BIOLOGY  
OF NORTH AMERICAN TABANIDAE<sup>†</sup>

Hine, J. S.

'03. Tabanidae of Ohio. Special Papers, Ohio State Acad. Sci., No. 5.  
 '06. Habits and life histories of some flies of the family Tabanidae, Tech. Ser., No. 12, Pt. 2, Bur. Ent., U. S. Dept. Agr.  
 '06a. A preliminary report on the horse-flies of Louisiana, with a discussion of remedies and natural enemies. Cire. 6, State Crop Pest Commission of La.  
 '07. Second paper upon the horse-flies of Louisiana. Bull. 93, Agr. Exper. Station La., State Univ.

MeAtee, W. L.

'11. Facts in the life-history of *Goniops chrysocoma*. Proc. Ent. Soc. Washington, 13: 21.

Walton, W. R.

'08. Notes on the egg and larva of *Goniops chrysocoma* (O. S.). Ent. News, 19: 464.

\*I do not know whether this character will hold good in a series as my material contains only one specimen of *nigrescens* (in very poor condition) and but 2 of *stygius*.

<sup>†</sup>Bull. Ill. State Lab. Nat. Hist., Vol. 4, Art. VI. (1895)

<sup>‡</sup>See also C. A. Hart's Art. VI, Vol. 4, Bull. Ill. State Lab. Nat. Hist. (1895)

Family *LEPTIDAE*

In the present paper I have limited this family to include only the genera placed in the subfamily Leptinae in Williston's Manual of North American Diptera. This grouping is not a new one, having been used by Brauer and several subsequent writers, and from a phylogenetic point of view it has much to recommend its general adoption.

## FAMILY CHARACTERS

*Larva*.—Head with a rather small protruded portion; maxillae not so prominent or so heavily chitinized as in Asilidae, closely resembling those of Tabanidae; maxillary palpi well developed; mandibles vertical, parallel, curved, and very long; retracted portion of head with a large arcuate upper covering which is not very heavily chitinized, and 4 elongate rods. Body in terrestrial forms circular in cross-section, distinctly tapered anteriorly, without pseudopods; lateral spiracles on metathorax and abdomen very small; in aquatic forms body slightly flattened and with paired abdominal pseudopods and dorsal and lateral filaments; anterior spiracles small; posterior pair large, located, in terrestrial forms, under a single flap-like process or at the base of an upper pair of pointed processes; in aquatic forms the spiracles are not distinguishable, and there are two rounded, protrusive blood-gills on apical segment below the bases of the long terminal appendages.

*Pupa*.—Head without projecting thorns; antennae short, swollen at base, slender apically, directed downward and slightly outward. Thoracic respiratory organs sessile (terrestrial forms); wings extending to second or third abdominal segment; hind legs extending to apex of wings or slightly beyond that point. Abdomen with a transverse series of bristles on each segment, the series becoming stronger towards apex of abdomen.

*Imago*.—Robust species with short antennae and stout legs. For characters to distinguish the family from other Brachycera see key to imagines of this division.

## HABITS OF LARVAE

Only one genus known to me is aquatic—*Atherix*. The terrestrial forms are found in rotten wood or in the ground in woods, generally under thick covering of leaves or under decaying logs or tree-stumps. They are predaceous, feeding upon larvae of other insects, and probably also upon worms. The species which I have reared were very

sluggish in the larval stage, but Beling mentions that one species in Europe is very active.

The larvae are frequently attacked and killed by internal nematode parasites.

#### HABITS OF IMAGINES

Some species are predaceous, feeding upon soft-bodied insects, but the greatest number are found upon flowers. Tree-trunks or fence-posts are favorite resting-places of the species of *Leptis*, where they invariably assume a position with the head downward. Some species of *Chrysopila* usually frequent the densest portions of woodlands, and others are found commonly only on marshy ground.

Several species of *Syphoromyia* are known to attack man and cattle in this country, inflicting very painful bites.

The females of the genus *Atherix* have a peculiar egg-laying habit. The eggs are deposited upon branches or twigs of willow or other trees overhanging streams. After oviposition the female does not fly away, but dies and remains attached to her egg-mass. A second female adds to the already deposited mass both her eggs and her body, and gradually others do likewise, until the combined mass of eggs and flies assumes considerable proportions, often containing several thousand dead flies. The larvae which hatch, drop from the mass into the stream below, where they pass the immature stages. The Indians in Oregon at one time collected the masses of eggs and flies and used them as food. An interesting account of this aboriginal utilization of nature's resources is given by Prof. J. M. Aldrich.\*

#### KEY TO GENERA†

##### LARVAE

1. Apical abdominal segment ending in 2 long stalk-like processes, which are fringed with long soft hairs; paired pseudopods present on abdominal segments; aquatic species. .... *Atherix*.
- Apical abdominal segment ending in 2 fleshy lips or in 4 tapering points, the spiracles situated at the base of the upper processes; paired pseudopods absent; terrestrial species. .... 2
2. Apical abdominal segment ending in 2 fleshy lips, an upper and a lower, the inner surfaces of which are brown. .... *Syphoromyia*.
- Apical abdominal segments ending in 4 pointed processes, the inner surfaces of which are pale. .... 3

\*Ent. News, Vol. 23, 1912, pp. 159-163.

†I have pupae of *Chrysopila* only, and can not give a key for the separation of the genera in this stage. For a key to the imagines use should be made of that to Leptinae in Williston's "Manual".

3. A small projection on outer under side of base of upper protuberance..... *Chrysopila*.  
 — No small projection on outer under side of base of upper protuberance..... *Leptis*.

### ATHERIX Meigen

#### GENERIC CHARACTERS

*Larva* (Pl. LII, Fig. 10).—Head small, entirely retractile, internally pyriform. Abdomen with lateral appendages and well-developed paired pseudopods which are armed with curved apical spines, as shown in Figure 10, Plate LII; apical segment ending in 2 long protuberances which are fringed with long hairs; 2 rounded blood-gills below base of apical protuberances.

*Pupa*.—Unknown to me.

*Imago*.—The species differ from those of other Leptidae in possessing the following combination of characters: third antennal joint reniform; basal antennal joint not thickened; arista dorsal; third tibiae with 2 spurs; front tibiae without apical spurs; anal cell closed; discal cell present.

#### HABITS OF LARVAE

The larvae are aquatic, living in flowing streams.

I have not seen any larvae of this genus from Illinois, the material before me being all from streams in Yellowstone National Park (S. A. Forbes) and from mountain streams in Montana (C. C. Adams).

#### HABITS OF IMAGINES

See under family.

### SYMPHOROMYIA Frauenfeld

I have not seen larvae of this genus, and the characters used in the key are from Beling's published description of a European species.

### CHRYSTOPILA Macquart

#### GENERIC CHARACTERS

*Larva* (Pl. LII, Fig. 6).—White. Tapered anteriorly, stout posteriorly, the apical segment ending in 4 stout processes, between the lateral pairs of which is a smaller process (Pl. LII, Fig. 11); head as in Figure 8. Anterior spiracles small, lateral metathoracic and

abdominal pairs minute, posterior pair large, circular, situated on ventral surface of the upper pair of apical processes. Body bare except for the usual 6 thoracic hairs.

*Pupa* (Pl. LII, Fig. 7).—Head without spines; antennae stout basally, slender apically, directed downward and slightly outward; thoracic respiratory organs sessile. Wings and legs short, extending to apex of first segment. Abdomen with spinose armature which becomes stronger apically; apical segment with stout processes which are not thorn-like.

*Imago*.—Distinguished from other genera by the following characters: third antennal joint conical or subconical, with a slender terminal arista; discal cell of wings present; 5 posterior cells; anal cell closed; hind tibia with 1 spur.

#### HABITS OF LARVAE AND IMAGINES

See under family.

#### KEYS TO SPECIES

##### LARVAE

1. Large species, 15 mm., or more, in length; neither the upper nor lower anal protuberances with well-defined lateral process (Pl. LII, Fig. 11) .... *ornata*.
- Smaller species, about 10 mm. in length; either the upper or lower anal protuberances, or both, with well-defined lateral process .... 2
2. Only the lower anal protuberances with well-defined lateral process (Pl. LII, Fig. 12) .... *quadrata*.
- Both upper and lower protuberances with well-defined lateral processes (Pl. LII, Fig. 9) .... sp. ?

##### PUPAE

1. Large species, 16 mm., or more, in length; apical abdominal segment with 8 thorns (Pl. LII, Fig. 13) .... *ornata*.
- Smaller species, about 10 mm. in length; apical abdominal segment with 8 strong thorns and several smaller ones (Pl. LII, Fig. 14) .... *quadrata*.

#### CHRYSOPILA ORNATA Say

*Leptis ornata* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 34.

*Larva* (Pl. LII, Fig. 6).—Length, 15–20 mm. White. Anterior spiracles brown, posterior pair black.

Head as in Figure 8, retractile and rather small, the permanently retracted portion subpyriform and consisting of a dorsal, rather poorly chitinized, arcuate plate, and 4 strong, though slender, rods. Body circular in cross-section; lateral areas limited by an incised line above and below; thoracic segments tapered anteriorly, anterior margins of all segments with fusiform areas ventrally and a band of locomotor setulae round the entire margin; apical segment (Fig. 11) with 4 large flattened, pointed protuberances, which have on their lateral margins a poorly developed process and between the upper and lower pairs a distinct tooth-like projection; each of the large protuberances with a long hair on inner surface near apex; spiracles large, round, situated near base on under side of upper pair of processes.

*Pupa* (Pl. LII, Fig. 7).—Length, 14–17 mm. Brown. Head without thorns; a pair of small warts above bases of antennae, the latter slightly elevated; cephalic capsule with a distinct wart, bearing a strong hair, just above each eye. Thoracic spiracles in the form of elevated, rough, wart-like protuberances, the opening linear; an area on anterior margin close to median line elevated in the form of an irregularly rugose wart; prothorax separated from mesothorax by an incised line which is not very distinct. Wings short, extending to apex of first ventral abdominal segment; legs short, apices of fore tarsi not reaching apices of wings, those of mid tarsi reaching them, and those of hind pair extending beyond them but curved inward so that they do not surpass the basal third of second abdominal segment. Abdomen more than twice as long as thorax, very slightly tapered apically; lateral areas defined by means of a line of punctures above and below; spiracles elevated, appearing like sharp vertical ridges; armature consisting of a girdle of stout, flattened spines near posterior margin of each segment from 2 to 7, the strength of the spines increasing slightly posteriorly; apical segment with 8 spines, 3 on each side, beginning at middle of side and extending upward, and 2 on ventral margin close together (Fig. 13).

The foregoing descriptions were made from specimens obtained at Cottonwood Grove, near Urbana, Ill., in April, 1916. One example obtained April 23, pupated May 9, and emerged May 25.

The specimens were found in the earth under leaves, and more commonly in slight depressions or under rotten wood where there was considerable dampness and a number of other insect larvae and worms.

A white nematode was found as an internal parasite. Hine has recorded the finding of the larva and pupa of this species in Ohio.

The range of the species is from the Mississippi eastward; it is common in Illinois.

CHRYSOPILA QUADRATA Say

*Leptis quadrata* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 35.

*Larva*.—Similar in general appearance to the larva of *ornata*, but differing noticeably in size, its length being only about 10 mm. The other principal distinction lies in the structure of the apical abdominal segment, which is as shown in Figure 12, Plate LII.

*Pupa*.—Very similar in structure to *ornata*. The abdominal spiracles are much smaller, however, and the apical segment has in addition to the 8 long spines borne by *ornata* several smaller ones, as shown in Figure 14.

The foregoing descriptions were made from specimens obtained at Cottonwood Grove, near Urbana, Ill., April 23, 1916. The larvae occurred along with those of *ornata* under a decaying log. The imagines emerged May 30 and 31.

CHRYSOPILA sp.

I have before me the larva of a third species of this genus. It is 12 mm. in length, and differs from *quadrata* in having the apex of the abdomen with well-defined lateral processes on both the upper and lower protuberances (Fig. 9).

This larva was found under fallen leaves at Charleston, Ill., August 22, 1910. It is almost certainly not full-grown, for taken so late in summer it would doubtless have remained in the larval stage till May of the next year.

CHRYSOPILA FOEDA Loew

*Chrysopila foeda* Loew, Berl. Ent. Zeitschr., 1861, p. 317.

The larva and pupa of this species were described by Coquillett in 1883\*. The descriptions present no characters that enable me to distinguish the larva and pupa from those which I have before me.

LEPTIS Fabricius

I have not seen the larva of any species of this genus.

I consider the species figured by Banks as *Anthomyia* sp., Fig. 117 in his paper on dipterous larvae†, as probably belonging to *Leptis*—certainly not to *Anthomyia*.

\*Can. Ent., Vol. 15, p. 112.

†The Structure of certain Dipterous Larvae, with particular Reference to those in Human Foods. Tech. Ser., No. 22, Bur. Ent., U. S. Dept. Agr., Pl. VI. (1912)

## Superfamily *Cyrtoidae*

I have provisionally placed in this superfamily two families, Cyrtidae and Nemestrinidae. I have seen the young larva and the pupa of Cyrtidae, but the other family is quite unknown to me. I have some doubts as to the propriety of linking these families together but can not suggest a better affiliation for Nemestrinidae, though the imagines are more dissimilar than is the rule in most superfamilies in Brachycera.

The larva of one species of Nemestrinidae has been described by Brauer. The species is recorded as being an internal parasite of coleopterous larvae.

### Family *CYRTIDAE*

*Larva*.—First-stage larva very active, armed on body with numerous spinose plates and single spines and with 2 long apical bristles, the latter serving as a means of propulsion in making the leaps which the larvae take before entering their hosts. On finding a location in the host the appearance of the larva changes radically, and it becomes maggot-like and very sluggish. The head is very small and almost entirely retracted. The prothoracic spiracles are minute, the anal pair much larger, slightly elevated, distinctly separated, and situated on the apical segment. The segmentation is rather indistinct, but the thoracic segments are clearly differentiated from the abdomen, being much more slender. The locomotor organs consist of a pair of slight elevations on segments 5-11 which are armed with minute spinules.

*Pupa* (Pl. LIII, Fig. 1).—Distinguished from every other family by the very large thorax, which exceeds the abdomen in length, by the short, stout abdomen, with its apex slightly recurved ventrally, by the 4 or 5 pairs of lateral abdominal spiracles, and by the entire absence of bristles or thorns on all parts of the body.

*Imago*.—Distinguished by the very small head, globose thorax, and very short, stout abdomen.

### HABITS OF LARVAE

The larvae are internal parasites of spiders, passing the winter within the body of their hosts.

### HABITS OF IMAGINES

The imagines are commonly rare, but occasionally they may be taken in considerable numbers flying round or settling upon dead

twigs of trees on which they lay their eggs. It is possible that the flies select these outstanding dead twigs because they are the haunts of many of the spiders that serve as the hosts of the larvae.

#### PAPERS ON NORTH AMERICAN CYRTIDAE

Johnson, C. W.

'15. Notes on the species of the genus *Acrocera*. *Psyche*, 22: 198.

King, J. L.

'16. Observations on the life-history of *Pterodontia flavipes* Gray. *Ann. Ent. Soc. Amer.*, 9: 309-321. (Contains the principal facts regarding the life history of the family, and a complete bibliography.)

Malloch, J. R.

'16. Some additional records of Chironomidae for Illinois and notes on other Illinois Diptera. *Bull. Ill. State Lab. Nat. Hist.*, Art. IV, 11: 341-342.

Melandier, A. L.

'02. Notes on the Acroceridae. *Ent. News*, 13: 179.

#### Superfamily *Asiloidea*

I have grouped together in this superfamily the families Mydaiidae, Apioceridae, Asilidae, and Bombyliidae. This arrangement is in accord with that of Brauer but is radically different from that of Osten Sacken and Verrall, both of whom place the families specified in different superfamilies.

#### SUPERFAMILY CHARACTERS

*Larva*.—Head in Mydaiidae and Asilidae with the exposed portion heavily chitinized, the maxillae broad, flattened dorso-ventrally, usually subtriangular when seen from above, the palpi normally distinct; labrum variable in length, generally pointed; mandibles knife-shaped, situated on each side of labrum and moving vertically between it and the maxillae; antennae small, generally difficult to distinguish. Body cylindrical or subcylindrical, segmentation distinct, seldom with secondary divisions, but if these are present there are also distinct locomotor protuberances on the abdominal segments; thoracic segments each with 2 long hairs on each side of venter. Apical segment somewhat variable, rounded in most genera but occasionally with a sharp upper posterior edge or, rarely, with 2 or 3 slightly chitinized projections on upper posterior margin, never with finger-like fleshy processes; prothoracic and anal spiracles distinct, the latter situated

on the penultimate segment, which in some Asilidae is very short and appreciably sunken. In Mydaidae and Asilidae there are very small functionless (?) spiracles on the metathoracic and basal 7 abdominal segments. In Bombyliidae the head is much less heavily chitinized than in the other families, but the presence of the anal spiracles on the penultimate segment indicates the relationship with the others. The abdomen has no distinct spiracles except the apical pair, and the apical segment has no hairs.

*Pupa*.—The armature of the head is usually sufficiently distinct from that of any other brachycerous family to distinguish the pupa, as no other possesses strong thorns on the antennae such as are shown in the figures for three of the families included in Asiloidea (Pl. LIII, Fig. 3; Pl. LIV, Fig. 7; Pl. LVI, Fig. 3). The only genus of this superfamily known to me that does not have these thorns is *Leptogaster*, but here the characteristic abdominal armature of the Asiloidea—consisting of strong curved thorns alternating with much weaker bristles in single transverse series—readily separates the pupa from those of Empidoidea. The pupae of Therevoidea have only one thorn on the base of each antenna and in some other respects differ from those of Asiloidea.

#### HABITS OF LARVAE

The larvae are either predaceous or parasitic, and may be considered beneficial—with the exception of those that are parasitic upon parasites of injurious insects, such as *Tiphia*, the parasitic enemy of white-grubs. The habits of the various genera are dealt with under the different family headings.

#### HABITS OF IMAGINES

The imagines of all Asilidae known to me are predaceous, feeding upon other insects. Some authors have recorded Mydaidae as feeding upon insects, but I have not seen the species known to me doing so. The imagines of Bombyliidae are, so far as I know, flower-frequenters, feeding upon nectar.

#### Family MYDAIDAE

The insects constituting this family have been considered as entitled to superfamily rank by Osten Sacken. Verrall has conceded their claim to separation from the other superfamilies in Brachycera, but links the Scenopinidae with them under the superfamily name Dermatina. Brauer, in one of his earlier papers, attempted to associate

Mydidae and Scenopinidae but separated them widely in his later, more comprehensive works, associating the scenopinids with the family Therevidae, and basing his argument for so doing upon the structure of the larva. In the present paper I have considered the family as belonging to the superfamily Asiloidea.

#### FAMILY CHARACTERS

*Larva* (Pl. LIII, Fig. 4).—White, usually very large and robust, with clearly differentiated segments; head rather large, under a low power appearing like a solid black cone; maxillae chitinized, pointed apically, not abruptly differentiated posteriorly, their inner surfaces clothed with stout, branched spines (Fig. 2); mandibles long, curved, slender, their apices extending to those of maxillae and beyond apex of the slender labrum; surface of head with several long hairs. Thoracic segments slightly tapering anteriorly, only a slight rounded shoulder to anterior margin of first segment; prothoracic spiracles rather small; metathorax with a pair of small spiracles; the usual 6 thoracic hairs, as in Asilidae, present. Abdominal and posterior thoracic segments slightly flattened dorso-ventrally and with a distinct lateral bead-like extension, the segments not as long as their dorsal width, those of abdomen with a rather abrupt transverse depression along their anterior dorsal margin except in the case of the apical 2; abdomen with small lateral spiracles on segments 1-7; middle ventral segments of abdomen each with a transverse series of 4 rather irregular pseudopod-like elevations near anterior margin; penultimate segment with 2 large round spiracles close to anterior margin, and a sharply defined transverse depression on its posterior margin; apical segment with a rather sharp ridge along the posterior margin, and armed with several hairs.

*Pupa* (Pl. LIII, Fig. 3).—Upper pair of cephalic thorns directed upward and slightly outward; lateral cephalic thorns 2 in number. Apices of wings extending beyond apices of mid tarsi; abdominal segments each with a girdle of stout thorns; apical segment with 2 stout, tapering terminal thorns.

*Imago*.—The elongate shape of the insects, together with their strong posterior legs and peculiar forwardly curved apical wing-venation, makes it a simple matter to identify the species in the field. The flies are usually deep black with contrasting reddish or yellowish color on wings, legs, or abdomen.

*Mydas clavatus* is the largest North American dipteron, and all the Mydidae recorded from this country are of considerable size.

## HABITS OF LARVAE

The larvae are predaceous, and are usually found in decaying wood, where their food consists principally of the larvae of wood-boring Coleoptera.

## HABITS OF IMAGINES

The imagines of *Mydas clavatus* are found upon flowers of milkweed principally, and although stated to be predaceous I have never found them with any prey. They fly most readily on bright, sunny days, and select the most exposed situations.

## MYDAS CLAVATUS Drury

*Musca clavatus* Drury, Illustrations of Natural History, Vol. 1, p. 103. (1770)

*Larva* (Pl. LIII, Fig. 4).—Length, 45–50 mm. White, head and spiracles black.

Head as in Figure 5; maxilla as in Figure 2. Apical segment slightly carinated on upper posterior margin.

*Pupa* (Pl. LIII, Fig. 3).—Length, 34–38 mm. Reddish brown, subopaque.

A strong upwardly directed pair of slightly divergent thorns on upper surface of head; antennal sheath with 2 strong downwardly and slightly outwardly directed thorns; a pair of short thorns, on a common base, at base of middle leg on margin of thorax and another pair above base of wings; apices of middle legs not extending to apices of wings. Armature of abdomen consisting of strong, flattened thorns, those of first segment directed forward, the others backward and slightly upward; apical segment ending in a pair of conical processes.

The above descriptions and the illustrations accompanying were made from three larvae and two pupae in our Laboratory collection. The larvae were obtained in Illinois, two being without data, the other having been taken at Pulaski, June 9, 1907. The pupal exuvia bear the following data: White Heath, Ill., May 26, 1910, larva found in rotten stump; and Quiver Lake, Havana, June 19, 1894.

The drawing of the larval head is incomplete anteriorly, the specimen being in bad shape, and showing neither maxillary palpi nor antennae. The general appearance of the larva is, however, sufficient to enable one to recognize it.

Walsh has described a species under the name *fulvipes*. The larval and pupal descriptions are very general and agree with the above as

far as they go. A comparison of specimens would be necessary to discover specific distinctions.

### Family APIOCERIDAE

The species of this family with two exceptions are unknown to me. They are, as far as known, confined to the south-western states and Mexico. There is a diversity of opinion regarding their superfamily location, and I have placed the family in Asiloidea with considerable hesitation, as the flies appear to resemble the family Nemestrinidae to some extent. A knowledge of the larval and pupal characters would undoubtedly throw much light upon their relationships.

### Family ASILIDAE

#### FAMILY CHARACTERS

*Larva*.—The structure of the segment which bears the posterior spiracles is generally the most readily appreciable character for the recognition of the larvae of this family, as it is sharply differentiated from the adjoining segments in most of the known forms, being occasionally very short and appearing in the form of a slightly depressed strip. *Leptogaster flavipes*, however, has this segment at least as long as the last one and not appreciably depressed. There is some variation in the form of the head in the different genera, but as far as I have seen they all present much the same general structure, the maxillae being particularly well developed, flattened dorso-ventrally and more or less triangular in shape. The thoracic segments are each armed with a single long hair on the middle of the latero-ventral line, and the anterior spiracle is well developed. The abdominal segments are well differentiated in those genera that I have examined, and except the apical one bare. The lateral spiracles on metathorax and abdomen are small but distinct. *Laphria*, as figured by Brauer, presents an exception to the general rule obtaining throughout the known members of the family in having the first 6 abdominal segments subdivided and the anterior portion of each with 6 wart-like protuberances—2 on dorsum and 4 on venter.

*Pupa*.—With the exception of *Leptogaster flavipes* all of the pupae known to me have the antennal sheath with 3 to 5 stout thorns (referred to in this paper as the "lateral cephalic thorns"), and the dorsal abdominal armature consisting of stout thorns in transverse series, the sizes alternating large and small on the central portion of each series. In one of my published papers on the pupae of these groups I

used this character to distinguish the pupae of Asilidae from those of Bombyliidae, the latter having alternating stout thorns and long slender hairs in the transverse armature of the abdominal segments, but owing to the occurrence in *Leptogaster flavipes* of an armature that differs almost as decidedly from that of other Asilidae as it does from Bombyliidae I have had to re-draft the statement of distinctions. In all the Bombyliidae known to me there are 2 closely approximated thorns on the lower central portion of the face, which are in some species fused almost to their apices; these thorns I have not found present in any species of Asilidae, not excepting *Leptogaster*. It is not improbable that further revision will be necessary as the pupae of more genera are obtained.

*Imago*.—The synoptic key to imagines of Brachycera presents a summary of the characters for the recognition of the imagines. The generic key in Williston's "Manual of North American Diptera" is sufficient for the identification of the genera.

#### HABITS OF LARVAE

All of the larvae of this family that I have found, are predaceous, feeding upon other insect larvae, either in decaying wood or in the ground, and may thus be considered generally as beneficial. Several species, such as *Promachus fitchii*, *P. vertebratus*, *Deromyia discolor*, *D. winthemi*, *Proctacanthus milberti*, *Erax maculatus*, and *E. acstuans* are instrumental in reducing the numbers of white-grubs in cultivated ground. *Asilus notatus* and *Leptogaster flavipes* I have found only in or near woods, and especially in or under decaying wood, and it is very probable that they confine themselves to attacks upon species that are found in such situations—Tenebrionidae and Cerambycidae particularly.

The transformation to the pupal stage is preceded by four or five days in a semi-quiescent condition, during which the gradual development of the imaginal parts may be clearly seen through the transparent skin of the larva. The pupa is capable of making its way through the ground either backward or forward, and prior to the exclusion of the imago makes its way to the surface, where the exuvium is left projecting half-way out of the ground after the imago has flown away.

#### HABITS OF IMAGINES

Like the larvae, the imagines are predaceous as a general rule, but very often some species may be taken on flowers, where they undoubtedly partake of the nectar. Some of the genera I have taken only on

flowers and never with prey, but my observations do not cover a long enough period to permit a definite statement as to the habits of the species of such genera as *Holcocephala*. The larger species, and particularly those that are of economic importance in the larval stages, are predaceous almost exclusively, attacking bees, wasps, and even other asilids, which they kill by inserting their proboscis through the thin membrane of the anterior portion of the thorax just below the dorsum, and through this opening extracting the body fluids.

I have found no parasitic enemies of either larvae or pupae, but the various stages of the species are preyed upon by insectivorous birds and mammals, and even by members of their own family.

#### KEYS TO GENERA AND SPECIES

##### LARVAE

1. Maxillae with an angular incision on outer side about middle; abdominal segments 1-6 each with a circle of 6 pseudopods on the anterior half. .... *Dasyllis* .... (p. 380).  
*Ceraturgus*? .... (p. 379).  
*Laphria*.
- Maxillae without an incision on outer side, posterior lateral extremity more or less distinctly angulated. .... 2
2. Very small species, averaging less than 10 mm. in length; mandibles aborted; penultimate abdominal segment as long as ultimate. ....  
*Leptogaster flavipes* (p. 377).
- Larger species, at least 15 mm. in length; mandibles extending at least midway to apices of maxillae. .... 3
3. Maxillary palpi at least 3 times as long as their diameter (Pl. LIV, Fig. 10). .... *Asilus notatus* (p. 385).
- Maxillary palpi at most twice as long as their diameter. .... 4
4. Antennae indistinguishable; short, robust species with distinct locomotor elevations on venter; maxillae without a distinct incision at base of palpi. .... *Deromyia discolor* (p. 384).
- Antennae distinct; if the species is short and robust the maxillae have a distinct incision at base of palpi (Pl. LIV, Fig. 5). .... 5
5. Posterior discal cephalic hair much nearer to antenna than to posterior margin of head; body robust, slightly flattened dorso-ventrally, the segments shorter than broad. ....  
*Promachus fitchii* (p. 383).
- Posterior discal cephalic hair nearly midway between antenna and posterior margin of head; body slender, rounded, segments longer than broad. .... *Promachus vertebratus*.

##### PUPAE

1. Head without sharp forward-directed thorns, at most with slight carinated elevations; abdomen with strong curved thorns and intervening slender hairs. .... *Leptogaster flavipes* (p. 377).

- Head with long, sharp, forward-directed thorns; abdomen with long and short straight thorns alternating..... 2
- 2. Thoracic spirae slightly elevated, rugose, without well-defined reniform area (*Promachus*)..... 3
- Thoracic spirae with distinctly elevated, well-defined, reniform area..... 5
- 3. Lateral cephalic process consisting of 3 thorns, the upper one bifid or sometimes duplicated so that the process appears quadrispinose; the last 5-6 thorns on lateral extremities of transverse armature of abdominal segments 2-7 very slender, their bases swollen but not fused; eighth ventral abdominal segment of male with 4 thorns..... *Promachus fitchii* (p. 383).
- Lateral cephalic process consisting of 3 simple thorns..... 4
- 4. Large species, averaging over 25 mm. in length; last 4-5 thorns on lateral extremities of transverse armature of dorsal abdominal segments 2-7 stout, flattened and rather wedge-shaped, their bases fused; intermediate short thorns present between the long ones on transverse series of seventh dorsal abdominal segment..... *Promachus vertebratus*.
- Smaller species, about 20 mm. in length; last 4-6 thorns on lateral extremities of transverse armature of dorsal abdominal segments 2-7 slender but not fused; intermediate short thorns absent from transverse armature of seventh abdominal segment..... *Promachus* sp.
- 5. Apices of fore tarsi extending very distinctly caudad of apices of wings (*Deromyia*)..... 6
- Apices of fore tarsi not extending to apices of wings..... 7
- 6. Ventral abdominal segments 3-7 each with an uninterrupted transverse median series of closely placed bristles. *Deromyia winthemi*.
- Ventral abdominal segments 3-7 each with 3 short transverse series of rather stout spines—one on each side and one in middle (i. e., the series twice interrupted)..... *Deromyia discolor* (p. 384).
- 7. Lateral cephalic process with 5 distinct thorns..... *Ceraturgus cruciatus* (p. 379).
- Lateral cephalic process with 4 distinct thorns..... *Dasyllis* sp.? (p. 382).
- Lateral cephalic process with 3 distinct thorns..... 8
- 8. A pair of strong bristles at middle of seventh ventral abdominal segment situated slightly caudad of the transverse series (sometimes also distinguishable on sixth) (*Erax*)..... 9
- Armature of seventh ventral abdominal segment consisting either of a complete transverse simple series of bristles or of a centrally interrupted series, caudad of which there is no armature on the segment..... 10
- 9. The pair of thorns at base of middle leg very short and stout; post-spiracular area of first abdominal segment with 7-9 spines; up-

per pair of thorns on apical segment directed upward.....  
 .....*Erax maculatus* (p. 387).

— The pair of thorns at base of middle leg rather long and slender; postspiracular area of first abdominal segment with 3 spines; upper pair of thorns on apical segment directed upward and backward, their apices slightly curved downward.....  
 .....*Erax aestuans* (p. 388).

10. Abdominal spiracles only moderately elevated; lateral cephalic process without a distinct protuberance on under surface at base of lower thorn; upper thorn on apical abdominal segment short, directed upward.....11

— Abdominal spiracles much elevated; lateral cephalic process with distinct protuberance on under side at base of lower thorn; upper thorn on apical abdominal segment long, directed backward and slightly upward, its apex deflected downward.....12

11. The pair of thorns at base of middle leg-sheath, in front of wing, obtuse at apices.....*Proctacanthus philadelphicus* (p. 385).

— The pair of thorns at base of middle leg-sheath, in front of wing, acute at apices.....*Proctacanthus milberti* (p. 385).

12. The pair of thorns at base of middle leg very short, the larger, posterior one not half as long as lower thorn of lateral cephalic process; seventh ventral abdominal segment with about 14 very long spines in a transverse series which is widely interrupted at center.....*Asilus notatus* (p. 385).

— The pair of thorns at base of middle leg long, the larger, posterior one as long as lower thorn of lateral cephalic process; seventh ventral abdominal segment with about 24 moderately long spines, the series not noticeably interrupted at center.....  
 .....*Asilus sericeus* (p. 386).

With the exception of those species whose descriptions follow, the species in the keys were described in my paper which appeared in 1915\*, to which students are referred for descriptions and other details.

LEPTOGASTER FLAVIPES Loew \*

*Leptogaster flavipes* Loew, Berl. Ent. Zeitschr., 1862, p. 193.

*Larva*.—Length, 9 mm. White, semitransparent, glossy; head parts dark brown.

Head viewed from above (dissected) as in Figure 7, Plate LIII, maxillae with slight downward direction and appreciable curve, maxillary palpi stout, at least twice as long as their diameter; (mandibles and labrum not distinguishable in specimen); dorso-central

\*Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. IV.

cephalic extension simple, its sides subparallel; lower, lateral cephalic extensions much narrower than dorso-central, their chitinized portions about half as long, divergent posteriorly. Thoracic spiracle rather small; each thoracic segment with a long hair on middle of the ventro-lateral line; sides of each abdominal segment except apical two with a large, round, convex highly glossy area; ventral surface of the same segments each with a transverse ridge-like elevation about one third from anterior margin, which is declivitous on the posterior surface and serves as a locomotor organ; penultimate, spiracular segment at least as long as ultimate, spiracles located well beyond its middle, their openings longitudinally elongated; dorsal surface of last segment not as high as preceding segment, armed with eight hairs, 2 on each side transversely at middle (1 submedian and 1 lateral) and 4 at apex; apex slightly papilliform.

*Pupa* (Pl. LIII, Fig. 6).—Length, 7 mm. Yellowish testaceous, slightly shining; cephalic armature and the strong abdominal thorns dark brown.

Cephalic armature weak, consisting of 2 slight elevations on upper central portion, the upper margins of which are carinate in front, the carinae closely approximated centrally; a weaker carinated elevation below the outer extremity of each of the upper pair; 3 small wart-like protuberances in a vertical series on median line, the upper in line with the inner extremity of the lateral protuberances, the lower with the bases of the antennal sheaths; antennal sheaths in the form of 2 moderately elevated ridges which taper to a point and are widely divergent apically; center of face with a small wart-like elevation which is slightly above the transverse line of the tips of the antennal sheaths; 4 long hairs on head—1 on each side of the upper pair of elevations and 1 on each side of face in vertical line with the bases of antennal sheaths and considerably below the level of the apices of these. Thoracic spiracles small, distinctly elevated, openings circular; disc of thorax with 8 long hairs—1 on each side of median line before middle and another beyond middle, and a widely separated transverse pair above base of each wing; wing extending beyond middle of second abdominal segment; apices of fore tarsi extending beyond apices of wings; apical 2 joints of mid, and 3 of hind, tarsi extending beyond apices of wings. First dorsal abdominal segment with 6 slender upright thorns (their apices turned backward) in a median transverse series, a single long hair between these thorns except in the middle pair, and laterad of the outermost thorn 4-5 long hairs; second segment with 5 very long, strong, backwardly curved hook-like thorns, the middle one very powerful, and single long hairs between all of the

pairs of thorns; following segments with similar armature except that there are 6 thorns, which are gradually reduced in strength until on the eighth segment they are very short and not much stronger than the long intervening hairs; lateral extremities of the transverse armature as on first segment; spiracles minute; postspiracular area of each segment with 4 long hairs; ventral segments each with 3 long hairs in a transverse series on each side; apical segment rounded, the terminal processes very small.

The foregoing descriptions are drawn from the exuvia of a male specimen reared by the writer. The larva was obtained at Cottonwood Grove, Urbana, Ill., April 23, 1916, in ground under a rotten log in company with several other dipterous larvae. It pupated May 5, and the imago emerged May 19. The specimen is a male, 11.5 mm. in length, which is a considerable increase over the 7 mm. of the pupa. No data were obtained as to the food of the larva.

The imagines of this species are not uncommon in Illinois.

#### CERATURGUS Wiedemann

I have before me larval and pupal exuvia of one species of this genus, and describe the species herewith. The larval and pupal stages have not been known hitherto.

#### GENERIC CHARACTERS

*Larva*.—I have before me only the cast skin of a larva which, with the exception of the head, is in very poor condition. It is not possible for me to discover the structure of the body, but the head is very similar to that of the larva I have considered as belonging to *Dasyllis*, the principal difference lying in the much less evident notch in the maxilla.

*Pupa*.—Separable from any other genus in the family that is known to me by the presence of 5 thorns on each antennal sheath. There are no small thorns on sides of face as in *Laphria*.

*Imago*.—The imagines of this genus are very robust insects, and their build, together with the long and dense black and yellow thoracic and abdominal hairs, gives them much the appearance of small bumblebees. They are predaceous, feeding upon a large variety of insects, including bees.

#### CERATURGUS CRUCIATUS Say

*Dasypogon cruciatus* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 52.

*Larva*.—Head flattened, the portion which is protrusive somewhat shield-shaped (Pl. LV, Fig. 1); maxillae not very acute at apices, the

notch on outer margin rather small; clear area surrounding palpi much larger than in *Dasyllis* sp. ?; posterior rods very compact, appearing as a single broad plate when viewed from above (Pl. LV, Fig. 1).

*Pupa* (Pl. LIV, Fig. 8).—Length, 17 mm. Yellowish testaceous, armature dark brown.

Upper cephalic thorns strong, much thickened at bases, acute and slightly curved downward at apices, separated by about their own length; lateral cephalic thorns 5 in number (Fig. 8); face unarmed. Thoracic spiracles distinctly elevated, the opening compressed (Fig. 6); spine at base of middle leg and in front of wing-base stout, short, and acute at apex; tubercle above base of wing carinate; wings extending to middle of second segment; apices of fore tarsi extending beyond apices of wings; mid tarsi with pulvilli large, their bases at apices of wings and their apices midway between apices of fore and hind pairs; hind tarsi extending nearly to apex of third segment of abdomen, the pulvilli very large. Abdominal spiracles elevated, of moderate size, uniform; basal dorsal segment with 6-8 strong backwardly curved thorns in a transverse series; segments 2 to 8 each with a transverse series of 6 strong thorns, between the pairs of which and for a short distance laterad of the outermost one on each side are 1 or 2 much shorter stout thorns, the apices of which are often bifid or trifid; segments 4-8 have in addition to thorns already mentioned 4 or more long bristles on lateral portions of series; apical segment with 4 subequal thorns, 2 above and 2 below, which project almost straight backward (Figs. 3, 4); postspiracular thorns 4-6 in number; ventral segments 1-3 without armature, the others with bristles in a transverse series near posterior margin, those on fifth and sixth segments sparse, the others very closely placed.

Described from one larval exuvium and two pupae submitted by J. A. Hyslop, which bear the following data: Wolfville, Md., May 14, 1914 (P. 125), and Wolfville, Md., larva collected November, 1913, pupated prior to June 1, 1914, adult emerged June 18, 1914.

#### DASYLLIS Loew

I have before me a young larva which I consider as probably belonging to this genus, and a full-grown larva, portions of a larval exuvium, and two pupal exuvia,—all of a species that undoubtedly belongs here.

## GENERIC CHARACTERS

*Larva*.—Head large and broad; maxillae with a distinct incision in their outer margin near the middle; maxillary palpi distinct; surface hairs on head long. Thoracic segments, as figured by Brauer for *Laphria*, longer than the abdominal, the latter more or less distinctly divided transversely, the anterior portion with a circle of 6 wart-like pseudopods; apical segment without chitinized teeth and shorter than subapical in young larva, longer in mature larva, and with a chitinized upper posterior margin bearing 3 teeth.

*Pupa*.—Distinguished from other asilid pupae by the armature of the head, the antennal sheaths each being quadrispinose.

*Imago*.—Robust species, usually with conspicuous silky hairs on abdomen.

## HABITS OF LARVAE

The larvae live in decaying wood, usually in standing trees, and prey upon Coleoptera and other wood-boring insects. The very strong cephalic armature of the pupa serves to cut a way to the surface in time for the emergence of the imago, even in trees whose wood is hard.

## HABITS OF IMAGINES

The imagines have a preference for sitting in the sunshine on exposed tree-trunks and fence-posts. They are predaceous, but occasionally are found on flowers. They attack large Diptera and Hymenoptera, victimizing even wasps and hive-bees.

## DASYLLIS sp.?

*Larva* (immature).—Length, 10 mm. Head (Pl. LIV, Fig. 12) broad and flat, maxillary incision of moderate depth; maxillary palpi slender, 2-jointed; mandibles short, not surpassing basal third of maxillae; dorsal posterior rod about 5 times as long as broad, of almost uniform thickness, slightly arcuate transversely; the paired lower rods slender. First thoracic segment much longer than the others. Each dorsal abdominal segment except the apical 2 with 4 pseudopod-like protuberances in a transverse series, the same ventral segments each with 2 such protuberances; transverse division of segments not distinct; apical segment rounded, no chitinized margin evident.

Described from a specimen obtained in woods at Urbana, Ill., April 12, 1892 (McElfresh and Snow).

The larval stage of a great majority of the larger Asilidae lasts over two years, and the specimen above described is evidently a first-year larva, as the structure of the maxillae and the form of the body diverge from the normal form for mature larvae.

*DASYLLIS* sp.?

*Larva*.—Length, 24 mm. White, with head, a large portion of dorsum of prothorax, and apex of last segment black.

Head very broad, the exposed portion, when seen from above, broader than long; maxillae trilobed owing to the presence of 2 distinct notches on the outer margin, the anterior one being very sharp, the posterior one slightly rounded and not so deep; apices of maxillae blunt; maxillary palpi distinctly 2-jointed, basal joint stouter and a little shorter than apical, the latter about twice as long as thick; mandibles very short, not extending beyond middle of maxillae; antennae indistinguishable; surface hairs strong but not very long. Prothorax with a brownish area on dorsum, the surface of which is studded with numerous small black chitinous spots; dorsal surface of thoracic segments finely striated; prothorax longer than metathorax; ventral hairs strong. Abdominal segments 1-6 each with an encircling series of pseudopod-like processes on their posterior half; penultimate, spiracle-bearing, segment distinctly shorter than ultimate; dorsum of last segment with 4 strong hairs in a curved transverse series just caudad of the depressed segment, and a chitinized plate at tip which is furnished with 3 short teeth and has a short hair ventrad of each lateral tooth; ventral surface of apical segment with 2 long hairs about middle and 2 near tip.

*Pupa* (Pl. LIII, Fig. 8).—Length: male 13 mm.; female, 25 mm. Brownish testaceous, distinctly shining; armature and wings dark brown.

Upper cephalic thorns strong, gradually tapered from base to apex, separated at apices by more than their own length; lateral cephalic armature consisting of 4 stout thorns; a short stout thorn on lower anterior eye-margin, and a smaller one on anterior portion of cheek; face as in Figure 1, Plate LIV. Thoracic spiracles very little above the level of thoracic dorsum, the aperture reniform, the area laterad of spiracle distinctly striate and with an irregular depression; thorns at base of middle leg 3 in number, flattened and highly polished; protuberances at base of wing in the form of a sharp thumb-nail-like vertical carina; apices of fore tarsi falling far short of apices of wings; apices of mid tarsi extending to apices of wings in male, slightly beyond them in female; claws and pulvilli of hind

tarsi very large, extending for their entire length beyond apices of wings and to base of third abdominal segment. Dorsal abdominal segments 1-7 each with a transverse series of short, stout, closely placed teeth, the lateral extremities of each series replaced by a series of 4-6 bristles; eighth segment with a widely separated pair of stout thorns; postspiracular bristles 4-5 in number, of very uneven strength, the lower one usually much stronger and longer than the strongest of the others; spiracles very slightly raised, openings almost round; apical segment with 4 slightly claw-like thorns, the upper pair much more widely separated than the lower; ventral segments each with a transverse series of bristles, the series becoming progressively stronger to eighth segment; apical segment unarmed ventrally.

The foregoing larval description was made from a specimen without data submitted by Dr. Edna Mosher for identification. The pupa was described from the exuvia of a male and female taken at White Heath, Ill., June 11, 1916. I found the specimens projecting from the decayed base of an apple-tree in a yard belonging to F. M. Peel. I did not find any imagines. June 2 I found one pupal skin in this locality, which I unfortunately lost, but as no others were visible on that date, the imagines must have emerged from the described exuvia during the interval from June 2 to June 11.

Adhering to the apical segment of one of the pupae, I found a portion of the larval exuvium. Unfortunately the head is missing, as is also a portion of the caudal extremity, but there is no doubt that the larva I have described here is that of this species, as there is a portion of the apical segment of the exuvium which agrees with that of the described larva.

#### PROMACHUS Loew

I have before me the larvae of two species of this genus and the pupae of three, as listed in the foregoing keys. I can not give a summary of larval characters that can be depended on to separate the species of this genus from all other Asilidae, but the pupae are readily identified by the form of the thoracic spiracles, which have no elevated, well-defined reniform area, thus differing from all other genera known to me.

#### PROMACHUS FITCHII Osten Sacken

*Promachus fitchii* Osten Sacken, Cat. Deser. Dipt. N. A., sec. ed., p. 234. (1878)  
*Trupanea apivora* Fitch, Third Rep. N. Y. State Ent., p. 251. Preoccupied.  
 (1859)

The larva of this species differs very greatly from that of *P. vertebratus*, being comparatively short and stout, with the segments very

much broader than long, whereas the segments in *vertebratus* are longer than broad (Pl. LIV, Fig. 9). The head also differs from that of the latter, as is shown in Figures 5 and 13, Plate LIV.

The pupae of the two species are very much alike in general structure, but may be separated as indicated in key. I have dealt with this stage of the three species known to me in a recently published paper\*.

Larvae and pupae of this species were submitted by Dr. E. P. Felt from New York State, and others in our collection are from northern Illinois. All the specimens were obtained where white-grubs were common, on which the larvae were observed feeding. They undoubtedly do much good in reducing the numbers of these grubs, thus more than offsetting the damage done by the imagines in destroying hive-bees.

#### DEROMYIA Philippi

I have the larva of one species of this genus and the pupae of two. The larva closely resembles that of *Promachus fitchii* in general appearance, but differs noticeably in the structure of the head, as shown in Figures 11 and 5, Plate LIV. The maxillary palpi are shorter than in *Asilus notatus*, and the apical segment is less distinctly carinated on its upper posterior margin. The armature of the thorax and the apical segment is similar to that of *Asilus* and *Promachus*.

The pupae differ from those of other asilids known to me in the characters given in key.

#### DEROMYIA DISCOLOR Loew

*Diogmites discolor* Loew, Berl. Ent. Zeitschr., 1866, p. 21.

*Larva*.—Length, 25–30 mm. White, head and spiracles blackish brown.

Head normal in size, the exposed portion as in Figure 11, Plate LIV. Segments not as long as broad, those of abdomen with distinct elevations on their anterior third which are in the form of rather pronounced pseudopods. Prothoracic and anal spiracles large, the lateral metathoracic and abdominal pairs very small. Apical segment not sharply carinated, much longer than the segment which bears the spiracles.

*Pupa* (Pl. LIV, Fig. 7).—Length, 25 mm. Brown, slightly shining.

\*A Comparison of the Pupae of *Promachus vertebratus* and *P. fitchii*. Bull. Brooklyn Ent. Soc., Vol. 11, pp. 66–68. (1916)

Differs from the pupa of *winthemi* only in the characters given in key to family. For full description of *winthemi* see paper referred to in paragraph following key.

The foregoing descriptions and comparisons were made from specimens of *discolor* sent to me by J. A. Hyslop from Hagerstown, Md.

The larvae of both species known to me feed upon larvae of Coleoptera that occur in fields and gardens.

#### PROCTACANTHUS Macquart

I have no identified larvae of this genus before me, but have obtained the pupae of two species—*milberti* Macquart, and *philadelphicus* Macquart—which very closely resemble each other. In my paper referred to at end of key I have given a full description of the pupae of *milberti* which it is unnecessary to reproduce here. The only difference between the pupae of *milberti* and *philadelphicus* that appears to serve as a reliable guide to their separation is found in the form of the pair of thorns above the base of the middle leg in front of the wing.

Both species occur commonly in Illinois. In the larval stage they feed upon white-grubs and other coleopterous larvae in fields and gardens.

#### ASILUS Linné

I have before me the larva of one species of this genus and the pupae of two.

The larva differs from this stage of other genera known to me in having the palpi much longer than broad, the head narrower posteriorly, and the apical abdominal segment slightly but distinctly carinated along its upper posterior margin. These characters may not apply to the larvae of other species of this genus, and I do not suggest that they are invariably applicable.

The pupae are very much alike structurally, but may be separated by the use of the characters stated in the key.

#### ASILUS NOTATUS Wiedemann

*Asilus notatus* Wiedemann, Aussereur. Zweifl. Ins., Vol. 1, p. 451. (1828)

*Larva*.—Length, 25–30 mm. White, head and spiracles black. Head with the protruded portion conical (Pl. LIV, Fig. 10); maxillary palpi more than 3 times as long as broad; antennae distinct.

Body cylindrical, the segments well defined, but little longer than broad, and without well-developed locomotor elevations; apical segment much longer than the one bearing the spiracles, slightly but distinctly carinated on its upper posterior margin and with the normal 8 long hairs—4 on dorsum and 4 on venter.

The foregoing details were obtained from specimens I obtained at White Heath, Ill., in April, 1916, some of which produced imagines in May. The larvae occurred in a much-decayed tree-stump in a wood along the Sangamon River. In the same stump occurred many larvae of *Rhamphomyia dimidiata* Loew, and also various coleopterous larvae, the latter including Elateridae, Tenebrionidae, Cerambycidae, and a few others that are usually found in rotten wood.

The pupa I described in the paper mentioned just after the family key.

**ASILUS SERICEUS** Say

*Asilus sericeus* Say, Jour. Acad. Nat. Sci. Phila., Vol. 3, 1823, p. 48.

*Asilus herminius* Walker, List of Ins. Brit. Mus., Dipt., Vol. 2, p. 410. (1849)

*Pupa*.—Length, 20 mm. Brownish testaceous, head and thorax very distinctly shining, abdomen less so, armature and spiracles deep brown.

Upper pair of cephalic processes stout, acutely pointed, apical half of dorsal surface smooth, basal half longitudinally, coarsely striate, bases irregularly rugose; viewed from above, processes slightly divergent apically, the distance between them at apices about equal to length of either thorn; lateral cephalic process as in Figure 2, Plate LV, the projection on under surface of base of lower thorn rather large; lateral pieces of mouth-parts not carinate at apices, the upper, central portion with a distinct protuberance. Thoracic spiracle very much elevated, apex compressed, the whole presenting the appearance of a short compressed tube; the pair of thorns at base of middle leg contiguous basally, anterior one very much smaller than posterior, the latter as large as lower thorn of lateral cephalic process (Fig. 3); protuberance above wing-base with a small chitinized process on lower portion of posterior margin; wing with very faint indications of discal protuberance; apices of wings extending to apices of fore tarsi. Abdominal spiracles similar in form to those of thorax but smaller; first dorsal segment with 12 stout, upwardly directed thorns the apices of which are slightly turned backward; segments 2-7 each with 6 long, stout, acutely pointed thorns, and between the pairs on second segment are either 1 or 2 shorter stout thorns which are not less than half as long as the large thorns, the latter becoming progressively

longer from first to seventh segment, and the short thorns progressively shorter and less numerous; laterad of the outer long thorn on each segment are 1 or 2 short thorns and from 4 to 7 long bristles; eighth segment with 4 short, stout thorns; postspiracular area of first segment with 7-8 bristles; ventral segments up to and including 7 each with a continuous transverse median series of closely placed bristles, the median pair appreciably stronger than those on either side of them; eighth segment with a pair of stout bristles on each side of disc; upper pair of thorns on apical segment long, tapering, directed backward and slightly upward; median pair not half as large as upper, ventral pair short (Pl. LV, Fig. 10).

The foregoing description is drawn from the pupal exuvium of a female obtained at Saratoga Springs, N. Y., June 8, 1915, and kindly submitted by Dr. E. P. Felt.

The species is represented by imagines from Algonquin and Albion, Ill.; and from Hot Springs, Ark.

The habits of the larvae are unknown to me.

#### ERAX MACULATUS Macquart

*Erax maculatus* Macquart, Dipt. Exot., Vol. 1, Pt. 2, p. 111. (1838)

*Erax lateralis* Macquart, ibid, p. 116.

*Erax ambiguus* Macquart, ibid, Suppl. 1, p. 84. (1845)

*Asilus interruptus* Macquart, Hist. Nat. Dipt., Vol. 1, p. 310. (1834)

*Pupa*.—Length, 20 mm. Yellowish testaceous, slightly shining; cephalic and abdominal armature glossy dark brown; apical portions of mouth-sheath and of wings brown.

Upper pair of cephalic processes stout, flattened and smooth above, rugose basally, distance between apices of thorns slightly exceeding length of either thorn; lateral processes consisting of 3 almost equally long blunt thorns, the lower with a slight angle at base on under side (Pl. LV, Fig. 4). Thoracic spiracle very broad, slightly elevated, reniform area smooth and slightly convex, margin carinate; the pair of thorns at base of middle leg very short and stout, about twice as long as their apical width (Fig. 5); protuberance above wing-base with a slight but distinct tooth near its lower posterior margin; wing with a small, sharp, discal protuberance at middle; leg-sheaths with a slight callosity near middle; apices of wings extending to midway between apices of fore and mid tarsi, apices of tarsi carinate on center of ventral surface. Abdominal spiracles broad, not twice as high as breadth at middle, slightly elevated; transverse armature of first

dorsal segment consisting of about 12 strong, upwardly directed, slightly backwardly turned thorns; second segment with 6 shorter, stronger thorns, between each pair of which are 3-4 very short, stout thorns, and laterad of the outermost of the long thorns are 4-5 short thorns and 6-7 long, slender spines in a transverse series which extends to postspiracular series; segments 3-7 as second except that the short thorns decrease in number progressively towards seventh and are almost indistinguishable on the latter; eighth segment with 2 long, widely separated thorns and laterad of these 2 short thorns and 1-2 spines; postspiracular area of first segment with 8-10 spines; each ventral segment with a transverse series of closely placed bristles on middle; sixth and seventh segments each with a strong pair of bristles slightly caudad of the regular transverse series, the pair on seventh segment very noticeably stronger than the other bristles; apical segment with the upper thorns broad, short, flat, and somewhat leaf-like, median thorns small (Pl. LV, Fig. 8).

The foregoing description is drawn from the pupal exuvium of a male obtained by C. G. Ainslee at Orlando, Fla., and kindly submitted for examination by J. J. Davis, of the U. S. Bureau of Entomology (Webster No. 10861 A).

The species is represented in our collection by imagines from Carbondale, Thebes, Metropolis, and Pulaski, all in the southern portion of Illinois; and by one specimen from Virginia.

The larva is predaceous upon white-grubs.

#### ERAX AESTUANS Linné

*Asilus aestuans* Wiedemann, Dipt. Exot., Vol. 1, p. 200. (1821)

*Pupa*.—Length, 18 mm. Yellowish testaceous, slightly shining; armature dark brown, glossy; apices of wings slightly browned.

Upper pair of cephalic processes sharp at apices, not noticeably flattened above; seen from above, slightly divergent apically, the distance between their apices distinctly greater than length of either thorn; lateral process with thorns sharper than in *maculatus* (Pl. LV, Fig. 6); apices of mouth-parts carinate. Thoracic spiracle much smaller than in *maculatus*, and more elevated, the reniform area slightly concave; pair of thorns at base of middle leg slender, sharp, the anterior one less than two thirds the length of the posterior (Fig. 7); protuberance above base of wing similar to that of *maculatus*; protuberance on middle of disc of wing very small; apices of wings extending midway between apices of fore and mid tarsi. Abdominal

spiracles large, slightly elevated; first dorsal segment with 14 long, slender, upwardly directed thorns, the apices of which are slightly deflected backward; segments 2 and 3 each with 6 long, slender thorns, between the middle and outer pairs of which, in each series, are 2 very short, stout thorns, and between the other pairs 1 such thorn, while laterad of the outermost large thorn on each segment are 4-5 short thorns and 4-6 long stout bristles; segments 4-7 each with 6 long spines as on 2 and 3, but the intervening short thorns are, except between the middle pair, reduced to 1, and those on lateral areas are also reduced in number until on segment 7 there are only 2 thorns and 4 bristles laterally; eighth segment with 1 spine and 1 bristle close to lateral margin well distad of transverse median line; armature of each side of apical segment consisting of a strong upwardly and backwardly directed thorn, the apex of which is slightly deflected, a moderately large median lateral thorn, and a small thorn on postero-ventral margin (Fig. 9); postspiracular area of first segment with 3 bristles, number on other segments 4-6; ventral segments each with a continuous transverse series of bristles near posterior margin, that on seventh segment consisting of about 24, and slightly caudad of the latter series is a pair of much stronger bristles, one on each side of median line.

The foregoing description is drawn from the pupal exuvium of a male submitted by J. A. Hyslop, of the U. S. Bureau of Entomology (Accession No. 2265).

The species is represented in our collection by imagines from Algonquin, Grafton, Quincy, Urbana, and Mt. Carmel—all in Illinois; and from Delaware Co., Pa., and from Kansas.

The larvae are predaceous upon white-grubs.

### Family BOMBYLIIDAE

#### FAMILY CHARACTERS

*Larva* (Pl. LVI, Fig. 1).—Very few of the species of this family are known or described in the larval stage, and the short characterization that is given here will in all probability require considerable modification to cover the entire family. The young larva of *Bombylius pumilus* has been described by Nielson\*, and differs very markedly from the mature form, being very active, and armed with thoracic and anal hairs, which are absent from the latter. Throughout this paper I have dealt only with last-instar larvae, and this point

\*Zool. Jahrb., Abth. Geogr. u. Biol., Vol. 18, 1903, p. 647.

must be borne in mind when using the keys to this stage. *Bombylius* is parasitic, or, speaking more precisely, inquilinous, in the nests of the bee genus *Andrena*, and in the larval metamorphosis from an active initial instar to a series of inactive instars presents an analogy to *Meloc*, a beetle which lives under similar conditions. Structurally the larvae of Bombyliidae closely resemble those of Asilidae, but, as far as my limited material permits me to determine, may be separated from the larvae of that family by the much smaller head with a slightly chitinized dorsal projection which is flattened anteriorly as shown in Figure 2, Plate LVI, by the normally crescentic form of the entire body, the head and the apex of the abdomen being slightly recurved ventrally, and by the absence or reduction in size of the thoracic and apical abdominal hairs. I have been able to detect the presence of thoracic hairs in some larvae of Bombyliidae, and Chapman has recorded their presence in the European species *Bombylius major*. He makes no mention, however, of apical abdominal hairs, and Nielson distinctly states that neither thoracic nor apical abdominal hairs are present in *Bombylius minor*. I have found no apical hairs on any of the larvae. The spiracles are small, the anal pair located upon the penultimate abdominal segment and difficult to distinguish; the lateral abdominal pairs are absent.

*Pupa*.—Like the larva, the pupa resembles that of the Asilidae in its general appearance, but as far as I have seen there is invariably present upon the central portion of the head-capsule, towards its lower margin, a pair of stout thorns which are in some species very closely approximated, or even fused except at apices. The only exception I know of is *Toxophora virgata* as described by Townsend, but the armature of the abdomen is typical of this family. Most of the Asilidae which I have reared or have before me have at least 3 strong thorns upon each antennal sheath, whereas I have found no bombyliid that has more than 2. This character can not be depended upon for the separation of the families, however, as *Leptogaster flavipes*, an asilid, has no thorns on the antennal sheath.

*Imago*.—The imagines of this family should be readily located in the family by the use of the synoptic key on a previous page. Williston's "Manual" presents a very good key to the genera.

#### HABITS OF THE LARVAE

All the species that are known in the larval stages are predaceous, parasitic, or inquilinous. A brief summary of the species attacked by the different genera follows. *Argyramoeba* occurs in the nests of

various Hymenoptera-Aculeata, including the genera *Anthophora*, *Megachile*, *Hoplomerus*, *Cemonus*, *Osmia*, *Trypoxylon* and *Odynerus*; *Hemipenthes* (*Anthrax* sens. Osten Sacken) is a hyperparasite, attacking hymenopterous parasites (*Ophion*, *Banchus*) and dipterous parasites (*Masicera*) of cutworm larvae; *Chrysanthrax fulvohirta* is a hyperparasite, the larva living in *Elis sexcincta*, a parasite of white-grubs; *Anthrax* sens. lat. parasitizes Lepidoptera in the larval stage, generally emerging when the host has pupated, *Mamestra*, *Panolis*, *Noctua*, *Agrotis*, and *Dichromia* being attacked—these records pertaining as far as I am aware to the subgenus *Hyalanthrax*; while the group containing the species with maculate wings attack hymenopterous and dipterous parasites of Lepidoptera, including *Masicera*, *Ophion*, and *Banchus*. *Aphobantus* is predaceous on the egg-masses of the locust *Caloptenus spretus*. *Systoechus* and *Anastoechus* are also predaceous on locust's eggs, the former being reared in this country from the egg-masses of *Caloptenus spretus*. *Bombylius* occurs in the nests of the bee genera *Andrena*, *Halictus*, and *Colletes*. *Toxophora* occurs in the nests of *Eumenes*, *Pelopocus*, and *Odynerus*. *Spogostylum* is parasitic upon five genera of Hymenoptera—*Pelopocus*, *Megachile*, *Cemonus*, *Osmia*, and *Xylocopa*—and two genera of Coleoptera—*Cicindela* and *Calicodoma*. *Calostoma* feeds upon the egg-masses of *Caloptenus spretus*. *Exoprosopa fascipennis* is a hyperparasite of the wasp *Tiphia*. *Sparnopolius fulvus* is parasitic on white-grubs.

#### HABITS OF THE IMAGINES

The imagines are without exception flower-frequenting, none of them, so far as is known, being predaceous. They are remarkably quick on the wing, their flight consisting alternately of quick dashes, in which the eye can barely follow them, and soaring pauses in mid-air. Their movements in settling upon a flower are very deliberate, but upon being disturbed they depart with a startling rapidity. A very large percentage of the species have the body covered with dense variegated pile, and the wings are very frequently marked with black or brown.

#### KEY TO PUPAE

1. Upper central pair of cephalic processes thorn-like, widely separated for their entire length; lateral cephalic process or processes thorn-like, but little if any shorter than the central pair.....2
- Upper central pair of cephalic processes stout, not thorn-like, contiguous for the greater portion of their length; lateral cephalic processes tubercle-like, much shorter than the central pair.....13

2. Apical abdominal segment terminating in a pair of long, tapering, backwardly directed thorns; first abdominal segment with the postspiracular hairs as long as head and thorax combined (*Spogostylum*) ..... 3

— Apical abdominal segment usually more or less truncated and with an upwardly and backwardly directed upper process and one or two smaller protuberances below it; first abdominal segment with the postspiracular hairs much shorter than head and thorax combined ..... 5

3. Head with 4 long thorns on upper anterior margin, the lower one on each side with a small protuberance at base on under side; the pair of thorns on lower portion of central line of face large, their bases contiguous; hairs on head and thorax very long; laterad of the short thorns the transverse armature of dorsal abdominal segments 2-6 consists of 2-3 long, widely placed rounded hairs ..... *Spogostylum anala*.

— Head with 6 short, stout thorns on upper anterior margin ..... 4

4. The pair of thorns on lower portion of central line of face small, their bases subcontiguous; hairs of abdomen, except those of verse armature of dorsal abdominal segments 2-6 consists of 12-20 long, closely placed, flattened hairs ..... *Spogostylum simson* (p. 393).

— The pair of thorns on lower portion of central line of face large, their bases, subcontiguous; hairs of abdomen, except those of basal segment, normal ..... *Spogostylum albofasciatum* (p. 395).

5. Antero-lateral margins of head each with 1 strong thorn, upper anterior margin with 2 such thorns, making 4 in all; labrum with a bifid thorn ..... *Chrysanthrax fulvohirta*.

— Antero-lateral margins of head each with 2 strong thorns, upper anterior margin with 2 such thorns, making 6 in all ..... 6

6. Labrum with a strong bifid thorn; wing with a median subcostal protuberance ..... *Aphoebantus mus*.

— Labrum unarmed ..... 7

7. The stout thorns on dorsal abdominal segments turned up at bases and apices ..... 8

— The stout thorns on dorsal abdominal segments turned up at apices only ..... 11

8. Lower lateral cephalic thorn with a palp-like organ projecting on its under surface at base, the apex of which is armed with several hairs ..... *Bombylius*.

— Lower lateral cephalic thorn without a palp-like organ on under surface ..... 9

9. Apical 3 segments without the dorsal transverse series of short thorns, armed only with slender hairs; no slender hairs interspersed between the short thorns of median portion of series on other segments ..... *Argyramoeba oedipus*.

- At least the penultimate and antepenultimate segments with dorsal transverse series of short thorns; slender hairs interspersed between the short thorns on all segments. .... 10
- 10. Wings extending to apex of third abdominal segment, their color pale. .... *Systoechus oreas*.
- Wings extending short of apex of second abdominal segment, fuscous apically. .... *Exoprosopa fasciata?*
- 11. Transverse armature of first abdominal dorsal segment consisting of a series of short, stout thorns on middle portion, and a number of long, slender, closely placed hairs on each side. .... *Exoprosopa fascipennis*.
- Transverse armature of first abdominal dorsal segment consisting of a few widely placed hairs, the middle portion either entirely bare or with very slight indications of small tubercles which do not appear as distinct thorns. .... 12
- 12. Lower one of the pair of lateral cephalic thorns simple apically, but with a small wart-like protuberance at base on lower surface, the small wart bearing 2 distinct hairs; wings without discal protuberances. .... *Sparnopolius fulvus*.
- Lower one of the pair of lateral cephalic thorns with a short sub-apical protuberance, the apex of thorn turned upward, base simple; wings each with a pair of protuberances, one about one fourth from base and the other near middle. .... *Anastoechus nitidulus*.
- 13. No well-developed pair of thorns on lower median portion of face. .... *Toxophora virgata*.
- A well-developed pair of thorns on lower median portion of face. 14
- 14. Eighth ventral abdominal segment without hairs on disc. .... *Hyalanthrax hypomelas*.
- Eighth ventral abdominal segment with hairs on disc. .... 15
- 15. Eighth ventral abdominal segment with 2 hairs on each side of disc; distance from the pair of thorns on lower central portion of head to apex of basal portion of sheath of mouth-parts about 4 times as great as distance from the latter to apex of proboscis. .... *Hyalanthrax lateralis*.
- Eighth ventral abdominal segment with 10-12 long hairs on disc; distance from the pair of thorns on lower central portion of head to apex of basal portion of sheath of mouth-parts about twice as great as distance from the latter to apex of proboscis. .... *Hyalanthrax alternata*.

#### SPOGOSTYLOM SIMSON Fabricius

*Anthrax simson* Fabricius, Syst. Antl., p. 49. (1805)

*Spongostylum simson* (Fabricius) Wiedemann, Dipt. Exot., Vol. 1, p. 122. (1821)

*Pupa*.—Length, 20 mm. Brownish testaceous, slightly shining; cephalic and abdominal thorns dark brown.

Head with 6 short, stout thorns on upper anterior margin, central pair more widely separated than the others, so that the whole appears as if divided into 2 groups of 3 each; the lower 2 thorns in each group apparently on a single base (Pl. LVI, Fig. 6); the pair of thorns on lower portion of central line of face almost conical, widely separated at base; 4 short hairs above base of upper cephalic thorns and one on each side of the lower central thorns. Prothoracic spiracles circular, rather large, margined with minute radiating rugae; metathoracic spiracles indicated by a small elevation; the normal thoracic hairs present; wing-cases without discal protuberance. Transverse armature of first dorsal abdominal segment consisting of a large number of closely placed flattened hairs, which are at least as long as head and thorax combined; dorsal segments 2-6 with the median portion of the transverse armature consisting of a number of short stout thorns which are turned up at bases and apices, giving them the appearance of furcate thorns with one point directed caudad and the other cephalad; seventh segment with 2 short simple thorns on each side of median line; laterad of the thorns on all segments are a number (12-20) of long flattened hairs which are very closely placed; postspiracular hairs very long, and, like the others, minutely pubescent; ventral segments each with 2-4 long flattened hairs in a transverse series on each side at middle; eighth segment with 4 hairs, one dorso-lateral and one latero-ventral on each side; apical segment terminating in 2 long, stout, slightly divergent, acutely pointed processes (Figs. 5, 7).

Described from a specimen submitted by W. L. McAtee which was obtained from a burrow of *Xylocopa virginica* in a pine-roofed porch at Plummers Island, Md., July 31, 1910.

Osten Sacken says of this species, without indicating his authority, "said to be a parasite of *Xylocopa virginica* in the United States"; and Davidson has recorded it as a parasite of *Xylocopa opifex* at Los Angeles, Calif.†

*Xylocopa virginica* occurs in the southern half of Illinois, the most northerly record we have being Charleston; and *simson* is represented in our collection by examples from Thebes, Grand Tower, and Grafton—all in the southern half of the state.

\*Biol. Cent. Amer., Vol. 1, p. 100. (1886)

†Ent. News, Vol. 4, 1893, p. 153.

## SPOGOSTYLOM ALBOFASCIATUM Macquart

*Anthrax albofasciatum* Macquart, Dipt. Exot., Vol. 2, Pt. I, p. 67. (1841)  
*Argyramoeba obsoleta* Loew, Berl. Ent. Zeitschr., 1869, p. 29.

*Pupa* (Pl. LVI, Fig. 3).—Length, 15–17 mm. Yellowish testaceous, slightly shining.

Differs from *simson* in having the pair of thorns on lower central portion of face larger and more closely placed, the clypeus with a sharp carina, the hairs on basal dorsal segment of abdomen flattened and all others slender, those of first segment a little shorter than head and thorax combined, and also in the shape of the apical segment, which at its tip is divided into two rather stout processes, each of which has a short projection on its inner surface near apex, and at the base on each side of segment 2 short thorns, as shown in Figure 4, Plate LVI.

I have seen pupae of this species sent me by Mr. Phil Rau, and a pupa and partly transformed larva submitted by Dr. Edna Mosher. I do not know the locality of the former, but the latter are from New York State.

Imagines of the species are commonly found throughout Illinois, and probably wherever its host, *Pclopoecus cementarius*, is found.

I suspect that several more species names will ultimately be added to the foregoing synonymy, as several species depend upon wing-markings—which are extremely variable—for their separation.

REFERENCES TO DESCRIPTIONS OF LARVAE AND PUPAE  
 OF NORTH AMERICAN BOMBYLIIDAE

*Spogostylum anale* Say, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 328. (1915)  
*Spogostylum anale* Say, Shelford, Ann. Ent. Soc. Amer., Vol. 6, No. 2, 1913, p. 213.  
*Chrysanthrax fulvohirta* Wiedemann, Malloch, Proc. Biol. Soc. Washington, Vol. 29, p. 67. (1916)  
*Aphoebantus mus* Osten Sacken, Riley, Packard, and Thomas, Sec. Rep. U. S. Ent. Comm., p. 262. (1880)  
*Systoechus oreas* Osten Sacken, idem, ibid., p. 266.  
*Exoprosopa fasciata* Macquart, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 329. (1915)  
*Exoprosopa fascipennis* Say, Malloch, ibid., p. 330.  
*Argyramoeba oedipus* Fabricius, Townsend, Am. Nat., Vol. 27, p. 60. (1893)  
*Sparnopolius fulvus* Wiedemann, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 331. (1915)

*Anastoechus nitidulus* Fabricius, Malloch, Proc. Biol. Soc. Washington, Vol. 29, p. 68. (1916)  
*Toxophora virgata* Osten Sacken, Townsend, Psyche, Vol. 6, p. 455. (1893)  
*Hyalanthrax hypomelas* Macquart, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 334. (1915)  
*Hyalanthrax lateralis* Say, Malloch, ibid, p. 332.  
*Hyalanthrax alternata* Say, Malloch, Proc. Biol. Soc. Washington, Vol. 29, p. 69. (1916)

### Superfamily *Therevoidea*

The superfamily name of Polytoma was used by Brauer to cover the families Therevidae and Scenopinidae. This grouping is followed in the present paper, but the name is changed to Therevoidea to conform to the rules governing zoological nomenclature.

#### CHARACTERS OF SUPERFAMILY

*Larva*.—Head with a cone-shaped anterior protruded portion, which consists of a dorsal sclerite overlapping the sides, and a small ventral sclerite which is not fused to the dorsal one; mandibles well developed; antennae and maxillary palpi distinct; dorsal posterior portion of head consisting of but one rod, the lower rods short or apparently absent. Thoracic hairs well developed. Abdominal segments 1-6 divided, the entire body appearing to consist of 20 segments exclusive of the head; anterior spiracles distinct; lateral abdominal spiracles absent; posterior spiracles situated on the antepenultimate segment.

*Pupa*.—Head with a pair of antennal thorns, which are directed laterad. Thorax with a long thorn at base of wing, or if this is absent the abdomen has 2 transverse series of spines on each dorsal segment except basal and apical.

*Imago*.—Eyes of males in Therevidae usually contiguous, in Scenopinidae distinctly separated; frons not sunken between eyes; proboscis never elongated. Body with or without wooly hairs; if the abdomen and thorax are somewhat leathery in appearance there are only 3 posterior cells on wing and the third antennal joint has no terminal arista. Legs without hairs or bristles in Scenopinidae, with or without small bristles in Therevidae.

### Family *THEREVIDAE*

#### FAMILY CHARACTERS

*Larva* (Pl. LVI, Fig. 10).—Very long and slender, tapering towards both extremities; head small, the posterior internal chitinized

dorsal extension in the form of a single stout rod with spatulate apex; mandibles strong, deflected in front and pointed at apices; antennae of moderate length (Pl. LVII, Fig. 1). Prothoracic spiracle distinct (Pl. LVI, Fig. 9); each thoracic segment with 2 hairs, one on middle of the latero-ventral line on each side. Abdominal segments 1 to 6 divided by means of a distinct circular constriction, so that the body appears to consist of 20 segments; posterior spiracles on antepenultimate abdominal segment; ultimate segment with 2 short points at apex and several surface hairs.

*Pupa* (Pl. LVI, Fig. 12).—Distinguishable from other pupae of the Brachycera by the presence of 2 thorns (antennal sheaths) on head and a long curved thorn at base of each wing. The abdomen has a single girdle of thorns on each segment, and the apical segment ends in 2 long, slender thorns which are contiguous except apically (Fig. 13).

*Imago*.—See key to families of Brachycera.

#### HABITS OF LARVAE

The larvae are found in the ground and also in decaying wood. I have found one species in wheat fields and in woods. They are predaceous, feeding upon various insect larvae, including wireworms, and under conditions of overcrowding or scarcity of other food they are cannibalistic.

#### HABITS OF IMAGINES

The flies are very active, especially during sunshine, when they may be found frequenting bare paths and sandy or exposed banks. I have no data upon their food habits except that they frequent flowers occasionally.

I have no record of parasitic enemies of any stage.

### PSILOCEPHALA HAEMORRHOIDALIS Macquart

*Thereva haemorrhoidalis* Macquart, Dipt. Exot., Vol. 2, Pt. I, p. 26. Imago. (1841)

*Psilocephala haemorrhoidalis* Macquart, Malloch, Bull. Ill. State Lab. Nat. Hist., Vol. 11, Art. 4, p. 334. Larva and pupa. (1915)

This species is the only *Psilocephala* that I have found in Illinois in the larval stage, although a number of other species of the genus are well represented in our collection of imagines. The habits are as previously mentioned for the family; descriptions of all stages are

cited in the above synonymy; and figures of the larva and pupa are given in the present paper (Pl. LVI, Figs. 9, 10, 12, 13; Pl. LVII, Fig. 1).

#### PSILOCEPHALA MELAMPODIA LOEW

*Psilocephala melampodia* Loew, Berl. Ent. Zeitschr., 1869, p. 9. Imago.

*Psilocephala melampodia* Loew, Felt, Bull. N. Y. State Mus., No. 155, p. 121. Larva and pupa. (1912)

This species was reared from a larva found under decaying pine bark at Albany, N. Y., April 8, 1911, and the larva and pupa were described by Dr. Felt, as indicated above.

The description of the larva is too short to permit of any comparison with that of *haemorrhoidalis*; but the pupa, judging from the description, has much shorter thorns at base of wing. Only a comparison of the larvae and pupae of the two species will furnish characters for their specific separation.

### Family SCENOPINIDAE

#### FAMILY CHARACTERS

*Larva*.—Closely resembles the larvae of the Therevidae. The smaller size and different habitat of the species readily distinguishes the larvae from those of that family without dissection, and dissection of the head provides characters for the separation of the species known to me. *Scenopinus* has the dorsal posterior chitinized extension parallel-sided apically, whereas *Psilocephala* has it spatulate, and while the latter has a pair of lower chitinized processes projecting beyond the posterior margin of the protruded portion of the head and evidently connected with the mandibles, *Scenopinus* has no such processes. Superficially the larvae are otherwise similar.

*Pupa*.—The pupa of this family is known to me only from descriptions. It is possible, however, to indicate that the species of the two families so far described may be separated by the character of the armature of the abdominal segments—Therevidae having only the apical girdle of spines on the abdominal segments while *Scenopinus* has an additional one on the middle of each segment.

*Imago*.—Distinguishable from Therevidae principally by the wing venation.

#### HABITS OF LARVAE

The larvae of *Scenopinus fenestralis* are predaceous, feeding upon larvae of other insects, and are found in a variety of situations—in fungi, in rotten wood, under carpets in houses, in roots of plants, etc.

## HABITS OF IMAGINES

Imagines of a few common species may be collected from windows. They are not predaceous, feeding as far as we have observed upon nectar or moisture.

## SCENOPINUS FENESTRALIS Linné

*Musca fenestrata* Linné, Fauna Suecica. (1761)

*Larva*.—Length, 18–20 mm. White.

Very slender, tapering towards both extremities. Head conical (Pl. LVII, Fig. 2). Thoracic hairs as long as or longer than the segments upon which they are situated; spiracles distinct (Pl. LVI, Fig. 11). Anterior division of abdominal segments 1 to 6 about one half longer than posterior; posterior spiracle about one third from anterior margin of antepenultimate segment; apical segment divided (Pl. LVI, Fig. 8), the surface hairs long.

The foregoing description was made from specimens obtained at Urbana, Ill., November 3, 1892, under a carpet, where they were feeding upon larvae of *Tinea tapetrella* (C. A. Hart).

The species was not reared and no pupae are available, the characters used in the key and elsewhere in this paper being obtained from published descriptions.

The species occurs commonly both in Europe and North America.

## Tribe ORTHOGENYA

This tribe of the Brachycera contains one superfamily, Empididoidea, and two families, Empididae and Dolichopodidae, both of which contain a very large number of species.

Superfamily *Empididoidea*

## CHARACTERS OF TRIBE AND SUPERFAMILY

*Larva*.—The larvae of both families as far as known, differ from others in Brachycera in having the labial plates and the longitudinal rods meeting at right angles, so that in profile they appear bent. The maxillary palpi are usually small and the antennae distinct. In all species that I have examined there are 4 slender elongate posterior cephalic rods, the larvae are amphipneustic, and the locomotor organs are more or less developed, consisting of paired pseudopods, of fusiform ventral areas armed with spines, or of transverse series of short spinules. The posterior spiracles are upon the apical abdominal seg-

ment and well separated, being sessile or nearly so in most species, only rarely elevated; this segment frequently has 4 short terminal protuberances.

*Pupa*.—The head very rarely has 2 long, strongly chitinized protuberances, and the antennae are short, directed downward and slightly outward, with 2 hairs on slight elevations at bases, and sometimes 2 or 3 short, compressed teeth on basal half. The proboscis in the Empididae that I have seen is much elongated, projecting much farther between the wings than in Dolichopodidae. Brauer has indicated that the former family possesses sessile thoracic respiratory organs, while the latter has these organs pedunculate and slender. I have reared one empid that has the type of respiratory organs which he ascribes to the Dolichopodidae, and this invalidates the structure of the respiratory organs as a differentiating character in these families. The proboscis, as above indicated, may prove useful in separating the families, but I suspect that *Ocydromyia* and several other genera of Empididae that have the proboscis short, can not be separated from Dolichopodidae by that character.

*Imago*.—Most species of Dolichopodidae are distinguishable at a glance from other Orthorrhaphae by their bright metallic blue or green color and their slender elongate legs. The few genera that are dull in color may be readily separated by their different habitus.

The Empididae are usually blackish or brownish slender species with elongate legs, those of the female frequently possessing a fringe of scale-like hairs on some or all of their tibiae or femora. The proboscis in the great majority of genera in this family is elongate, slender, and fitted for piercing. For synoptic characters see key to imagines of Brachycera.

### Family *EMPIDIDAE*

#### FAMILY CHARACTERS

*Larva*.—The labial plates and the longitudinal rods of the head meet angularly, so that in profile they appear bent. The labium consists of 2 arcuate bands, which are contiguous and form an angle anteriorly; the mandibles appear in the form of a lunate plate, as shown in Figures 4 and 6, Plate LVII. The antennae are well developed, consisting of 2 joints. The posterior spiracles are situated upon the last segment, well separated and occasionally slightly elevated; the last segment is rounded or has a slight protuberance below at tip.

I have the immature stages of only two genera in my material, and to attempt a generalization of the family and a presentation of the characters for their separation from Dolichopodidae, with which I am almost unacquainted, is impossible.

*Imago*.—See family key.

#### HABITS OF LARVAE

The European species are much better known than the American, and from data supplied by workers on that continent, and from my personal observations, it is evident that the larvae are for the most part either predaceous or scavengers, living in the ground or in wood in a more or less advanced stage of decay. Some species are aquatic or semiaquatic.

#### HABITS OF IMAGINES

The imagines are in the great majority of cases predaceous, feeding upon other insects and occasionally attacking species of the same family or individuals of the same species. There are published records that the male of some genera catches the prey which serves as a meal for the female during copulation. The sexes of *Tachydromia* and allied genera catch their own prey, usually while running on tree-trunks. Many species have a habit of flying in swarms, remaining in one place and flying with an up and down movement similar to that adopted by certain Chironomidae. Terrestrial species usually fly in this manner on the leeward side of a tree, bush, or other sheltering object; but the aquatic forms and those living in damp earth perform their aerial dance over the surface of a pool in a stream, or over a pond or lake.

Despite their predaceous habits nearly all genera occur upon flowers, sometimes in large numbers.

#### RHAMPHOMYIA DIMIDIATA Loew

*Rhamphomyia dimidiata* Loew, Berl. Ent. Zeitschr., 1861, p. 325.

*Larva*.—Length, 7–9 mm. White, head black. General shape musciform, tapered anteriorly, blunt posteriorly. Head when seen from above, as in Figure 4, Plate LVII; the antennae well developed, 2-jointed. Thoracic spiracles small. Abdomen with 8 segments; circular in cross-section; segments broader than long, without distinguishable locomotor organs, apical segment rounded; spiracles large, disc-like, separated by a space about equal to width of a spir-

acle, spiracular openings irregular; a group of 3-4 hairs on a slight elevation below each spiracle.

*Pupa* (Pl. LVII, Fig. 5).—Length, 6-8 mm. Yellowish testaceous, the armature brown.

Head without prominent thorns, the bases of antennae produced in the form of carinate ridges; proboscis thick, elongated. Thoracic respiratory organs in the form of short stalks; surface hairs as in figure. Abdominal spiracles elevated; armature as in figure, the bristles rather slender.

The foregoing descriptions were made from material obtained by me at White Heath, Ill., April 2, 1916, from a much-decayed tree-stump. I reared a number of specimens of both sexes under laboratory conditions, the specimens emerging from ten days to three weeks from date of collection of the larvae, the average duration of the pupal stage being 8 days. No parasites were obtained.

No imagines of this species were obtained by collecting in the locality where the larvae were taken, and the species is unrepresented in our Laboratory collection except by the reared examples.

Originally described from Maryland and Massachusetts, the species has not, so far as I know, been subsequently recorded.

#### DRAPESTIS Meigen

I have seen the larval and pupal exuvia of but one species of this genus, and these are not in very good condition. This species, *nigra* Meigen, is slightly less than 1.5 mm. in length, and as the exuvia were dried out when I found them the details are not as clear as they would be in fresh material. The drawings, however, give a good idea of the general appearance of the parts available for study.

#### HABITS OF LARVAE

The larvae occur under bark and in decaying wood. Their very small size makes their detection difficult. They spin a remarkably tough cocoon, in which they pupate. The cocoon is densely coated with minute particles of the wood in which the larvae live.

#### HABITS OF IMAGINES

The imagines are very common on tree-trunks and fences, running with great rapidity, and are predaceous upon small insects. They resemble the dolichopodid genus *Medeterus* in both larval and adult habits.

## DRAPESTIS NIGRA Meigen

*Drapetis nigra* Meigen, Syst. Beschr. Eur. Zweifl. Ins., Vol. 6, p. 344. (1828)

*Larva*.—Length, 2-2.5 mm. White.

Musciform; head from above as in Figure 6, Plate LVII. Abdomen with locomotor spinules in a rather broad band on anterior margin of segments; posterior spiracles large, separated by slightly more than the width of a spiracle; a slightly darkened and raised transversely elongated area below spiracles armed with a few hairs.

*Pupa* (Pl. LVII, Fig. 7).—The pupa differs in many respects from that of *Rhamphomyia dimidiata*. The chief distinctions lie in the much elongated respiratory organs of the thorax, and in the armature of the abdomen, the latter consisting of a dense covering of small spinules on the greater portion of the dorsum of all segments.

The specimens from which the foregoing descriptions were made, are the exuvia of a female reared from a rotten stump at Crystal Lake Park, Urbana, June 10, 1916. With this specimen were many larvae of *Clusiodes flaviseta* Johnson.

*Drapetis nigra* is a European species that has previously been recorded from South Dakota and Canada.

## PAPERS ON THE BIOLOGY OF NORTH AMERICAN EMPIDIDAE

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'99. A Balloon-making fly. Am. Nat., 33: 809-812.

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(Notes on the life history and descriptions of larva and pupa of *Roederiodes juncta* Coquillett are given on pp. 581-582.)

## Family DOLICHOPODIDAE

I have not succeeded in obtaining all stages of any species of this family, and little is known of the early stages in America, only one species in this country being fully described—by Johannsen and Crosby. I have before me the larvae of two species, which were described by Mr. Hart in his paper "On the Entomology of the Illinois River and Adjacent Waters" cited in the list of publications at the close of this section. These larvae were referred to Brachycera without being assigned to any family. The European species are much better known, though few of the descriptions are clear upon many of the essential points. In view of these facts it would be folly to at-

tempt a characterization of the larval and pupal stages of the family, but in pointing out the meagerness of our knowledge I hope I may help to remedy it by directing the attention of some student to this line of investigation, which will repay him more satisfactorily for the time and energy expended than will the writing of new descriptions of imagines the life history of which is entirely unknown.

#### HABITS OF LARVAE

The larvae have been recorded as predaceous upon other insect larvae. They are found in a variety of situations, but a great majority are aquatic. *Dolichopus*, *Hydrophorus*, and *Campsicnemus* are among the aquatic forms, and *Medeterus* and *Thrypticus* are found in plants, the latter in the stems of low plants, and the former in burrows of other larvae or under bark of trees. The larva of *Aphrosylus* occurs among seaweed on the shore.

#### HABITS OF IMAGINES

Many of the species occur upon flowers, and several genera, such as *Chrysotus*, *Dolichopus*, and *Psilopus* occur commonly upon leaves of plants. They undoubtedly feed upon nectar, but even *Psilopus* will destroy small insects, as I have seen it catch a small thrips, and though it did not kill it, its actions were such that I am convinced that the species are predaceous. *Medeterus* I have seen feeding upon a specimen of *Forcipomyia*. *Aphrosylus* I know from observation to be predaceous, and *Hydrophorus* and *Campsicnemus* have the same habit.

#### NOTES ON DESCRIBED SPECIES

The only identified species that has been recognizably described from North America is *Thrypticus muhlenbergiac* Johannsen and Crosby. From an examination of the figures and description of the larva of this species I find that it agrees with that of *T. smaragdinus* Gerstaeker, a European species, in being peripneustic, and in having a transverse band of locomotor spinules on 8 of the ventral segments, the spinules of the anterior series of each band stronger than those of the 2 or more posterior series. The general shape of the European larva is more uniform than that in the figure of the American, but I suspect that the latter represents a specimen just prior to pupation. The cephalic capsule of the pupa of both species is armed with a pair of protuberances, those of *smaragdinus* being strong and stout, while

those of *muhlenbergiae* are slender and almost hair-like. The thoracic respiratory organs in both species are stalk-like. The figure and description of our species give us no details of the legs and wings, but *smaragdinus* is figured as having the wings extending to the apex of second abdominal segment, the apices of fore tarsi to middle of fourth, those of mid tarsi to apex of fifth, and those of hind tarsi almost to apex of abdomen. Both species have a single transverse series of short spines on each dorsal abdominal segment, and pedunculate spiracles on lateral margins of segments 1 to 4. The apical segment in *muhlenbergiae* is armed with 4 thorns.

It will be seen from the foregoing that the pupae offer as characters for distinguishing them from the pupae of *Drapetis* the pedunculate abdominal spiracles and the single transverse series of dorsal abdominal spinules. The larvae I can not fully compare because I have only a cast larval skin of *Drapetis* which affords no evidence as to whether there are lateral abdominal spiracles in that stage. The locomotor spines differ somewhat, however, and if the figure of *muhlenbergiae* is dependable the head also differs in having a single saddle-like dorsal plate.

Both species of *Thrypticus* above mentioned live in stems of plants; neither species forms a cocoon like that of *Drapetis*.

*Medeterus* lives in burrows of wood-boring larvae and also under bark. Dr. E. P. Felt has recorded the larvae as feeding upon those of *Miastor*. No species of this genus has been described in either the larval or pupal stage from America. Perris has described the larva and pupa of *Medeterus ambiguus*, a European species. The larva of this species has the head very similar to that figured in the present paper for *Drapetis* (Pl. LVII, Fig. 6). The distinctions, judging from Perris's figures, lie in the presence of only one series of locomotor spinules on the abdominal segments, and in the tapering apical abdominal segment, which ends in 4 short subcontiguous points, at the apices of the upper and larger pair of which are located the posterior spiracles. No mention is made of lateral abdominal spiracles, but the prothoracic pair are figured. The pupa has the pair of cephalic spines similar to those of *Thrypticus*, but slightly ventrad of them are 2 much smaller protuberances. The thoracic respiratory organs are long and slender. The fore tarsi do not extend beyond apices of wings, the mid pair reach middle of fourth abdominal segment, and the hind pair extend to middle of sixth. The dorsal abdominal segments possess 2 linear transverse series of spinules.

A species of *Systemus* described by Laboulbène differs in the larval stage from *Medeterus* in having the locomotor spinules situated upon

ventral fusiform transverse areas, and in the shape of the apical segment, the latter being of uniform width to apex, and having 4 short, widely separated protuberances, the lower pair distinctly longer than the upper, the latter bearing the posterior spiracles.

The pupa of this genus resembles closely that of *Medeterus*, but the thoracic respiratory organs are figured as long as head and thorax together, with distinctly tapered apices. The fore tarsi extend beyond the apices of the wings and the dorsal abdominal segments each have a band of locomotor spinules consisting of about 3 series, the anterior one of which is much stronger than the others. Neither *Medeterus* nor *Systemus* has the abdominal spiracles pedunculate.

Brauer figures the larva of *Dolichopus aeneus* De Geer. The head shows an upper T-shaped piece whose anterior portion is considered as the labrum, and on each side of this plate are the sickle-shaped mandibles; the maxillae are not chitinized and their palpi are short and blunt; the antennae consist of 2 joints. The posterior cephalic rods are represented as slender, the upper pair slightly broadened posteriorly and exceeding in length the lower pair. The body is figured with 7 pairs of pseudopods, the apices of which are armed with rather strong spinules. The apical segment terminates in 4 short subequal protuberances.

The pupa has the cephalic capsule with 4 small warts above, and below these 2 others. The thoracic respiratory organs are very long and slender.

The larva of a species of *Dolichopus* is figured herein (Pl. LVII, Fig. 3). This is Larva (b) of C. A. Hart's paper previously referred to, which he described at the conclusion of the part dealing with Brachycera. All three species therein referred to are of this genus.

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Urbana, Illinois, March 16, 1917.

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